A MANUAL OF
SURGICAL ANATOMY

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BY

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SECOND EDITION, REVISED AND ENLARGED

EDINBURGH

E. & S. LIVINGSTONE

15, 16 & 17 TEVIOT PLACE

1914

First Edition . . . *1910*
Second Edition . . *1914*

PREFACE TO THE SECOND EDITION

In this edition the work has been extended by about a hundred pages and several fresh illustrations have been added.

The author is especially indebted to Dr Calder of Aberdeen University for his assistance in reading the proofs. The new illustrations are the work of that well-known anatomical artist—Mr J. Grieve.

The author also desires to thank the publishers for their uniform kindness and courtesy.

Surgeons' Hall, *May* 1914.

PREFACE TO THE FIRST EDITION

Having been asked by many of his students to write a short work on Surgical Anatomy, the author undertook to do so chiefly from material already prepared by him and used in his lectures.

This little volume is offered to the student, not in any sense as a text-book, but merely as outlines to be filled in by the study of larger works, attendance at lectures, and, above all, by diligent work in the dissecting room.

The details of Surface Anatomy have been omitted for the sake of brevity, and because they have been treated fully by the author in a previous work.

The illustrations are largely original, but the author is indebted to Mr A. Scott Skirving, C.M.G., F.R.C.S., for courteous permission to use some illustrations from his book on "Applied Anatomy."

The kindness and assistance of the publishers are also gratefully acknowledged.

Surgeons' Hall, *30th September* 1910.

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SECTION I

THE SUPERIOR EXTREMITY

SURFACE ANATOMY OF THE REGION OF THE SHOULDER

FIRST palpate the clavicle, the acromion process of the scapula, and the spine of the scapula. At the junction of the middle and outer thirds of the anterior aspect of the clavicle a small irregular projection, the deltoid tubercle, is sometimes present; this must not be mistaken for a fracture. The sternal and acromial extremities of the clavicle may be unduly prominent and simulate a dislocation. Remember that the epiphyseal part of the acromion process of the scapula is often found as a separate bone. Two theories have been put forward to explain this condition : (*a*) that it is an un-united fracture, and (*b*) that it results from the failure of union of the epiphysis.

The rounded prominence of the shoulder below the acromion is formed by the deltoid, supported by the great tuberosity of the humerus; the latter may be palpated through the muscle on rotating the bone. Flattening of the shoulder is produced either by a dislocation of the shoulder-joint or from atrophy of the deltoid. In dislocation, the deltoid becomes flattened as it ceases to be supported by the great tuberosity of the humerus.

The delto-pectoral furrow lodges the cephalic vein, the humeral branch of the thoracic axis artery, and a

lymphatic gland. In this sulcus the coracoid process may be felt on pressing backwards and outwards; it is overlapped by the inner fibres of the deltoid.

Note that the delto-pectoral groove leads to the infra-clavicular fossa. When the head of the humerus is dislocated below the clavicle or the coracoid process, the fossa is replaced by an eminence. The fossa lies over the clavi-pectoral fascia (costo-coracoid membrane) and the first part of the axillary artery. In this situation the artery can be compressed against the second rib.

THE AXILLA.

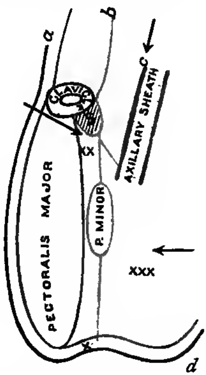
The axilla is pyramidal in shape, the apex being directed upwards and the base downwards. The anterior axillary fold is formed by the pectoralis major, and internally this is supplemented by a small portion of the pectoralis minor. The posterior fold is produced by the latissimus dorsi and the teres major. Normally, the posterior fold is on a lower level than the anterior fold, but this arrangement is often reversed when the shoulder is dislocated.

Boundaries.—Anterior—the pectoralis major, pectoralis minor, and clavi-pectoral fascia. Posterior—the subscapularis, latissimus dorsi, and teres major. Externally—the head and surgical neck of the humerus, coraco-brachialis, and short head of the biceps. Internally—the upper four or five ribs, the corresponding intercostal muscles, and digitations of the serratus anterior (magnus). Floor — the axillary fascia uniting the anterior and posterior folds. Apex—a small triangular space between the clavicle, first rib, and the upper border of the scapula. Through this opening the axillary cavity is continuous with the posterior triangle of the neck, and through it the vessels and nerves reach the axilla from the lower part of the neck.

The *contents* are—(i.) axillary artery and branches; (ii.) axillary vein and tributaries; (iii.) brachial plexus and branches; (iv.) lateral cutaneous branches of the second and third intercostal nerves, the former being termed the intercosto-humeral and joining the lesser internal cutaneous (nerve of Wrisberg); (v.) lymphatic glands; and (vi.) fat and areolar tissue.

Fascia of the Axilla.—(Fig. 1) will help the student

Fig. 1.—Diagram of Axillary Fascia and Sites of Abscesses.



a (Blue), Superficial layer of cervical fascia
b (Green), Pretracheal layer of cervical fascia.
c (Red), Prevertebral layer of cervical fascia.
d, Integument.
x, Site of abscess between integument and axillary fascia.
xx, Site of abscess in anterior wall of axilla.
xxx, Site of abscess in cavity of axilla.

to understand the relations of the cervical fascia to the fasciæ around the axilla. The superficial layer of the cervical fascia is attached to the anterior surface of the clavicle, and here it is brought into continuity with the pectoral fascia, which in turn passes across the base of the axilla as the axillary fascia. The second or pretracheal layer is fixed to the under surface of the clavicle, and then forms (from above downwards) the sheath of the subclavius, the clavi-pectoral fascia, the

sheath of the pectoralis minor, and the suspensory ligament of the axilla. Lastly, the clavi-pectoral fascia sends a slip to the axillary sheath, the latter being mainly derived from the third, or prevertebral, layer of cervical fascia.

Externally, the axillary fascia blends with the deep fascia of the upper arm (the brachial aponeurosis), and internally it becomes continuous with the fascia covering the serratus anterior.

Axillary Abscesses—Abscesses may occur either (*a*) superficial to, or (*b*) beneath the axillary fascia, or (*c*) in the anterior wall of the axilla. When superficial they are usually small and circumscribed.

An abscess in the anterior wall results from the suppuration of one of the lymphatic glands resting upon the clavi-pectoral fascia. Infection reaches the glands *via* the lymphatic vessels which accompany the cephalic vein. These lymphatics drain the outer side of the arm and the front and outer aspect of the shoulder. Abscesses in the anterior wall usually point at the junction of the anterior axillary fold with the thorax.

The deep-seated axillary abscess may be a sequel of pus in the visceral compartment of the neck, Pott's disease in the upper thoracic vertebræ, empyema, or of a tubercular rib. Also it can arise from infection of one of the axillary glands, the micro-organisms travelling along the lymphatic vessels in relation to the basilic vein.

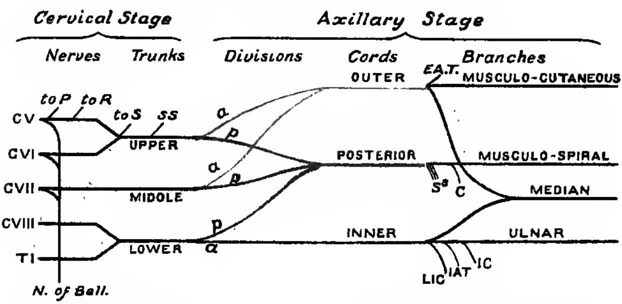
The deep-seated abscess shows a marked tendency to burrow upwards, being prevented from reaching the surface by the strong axillary fascia already mentioned. These abscesses often extend into the lower part of the neck through the apex of the axilla.

When opening an axillary abscess, a horizontal incision should be made midway between the anterior

and posterior axillary folds cutting towards the chest; this will avoid the axillary vessels on the outer wall, the subscapular artery on the posterior wall, and the lateral (long) thoracic artery on the anterior wall.

Clavi-pectoral fascia (costo-coracoid membrane).—This fascia stretches horizontally from the coracoid process to the first rib. It bridges over the gap between the clavicle and the pectoralis minor. Along the lower border of the subclavius muscle it forms a tough band, the costo-coracoid ligament. As already mentioned,

Fig 2.—Diagram of Brachial Plexus.



a, Anterior division.
p, Posterior division.
toP, Twig to phrenic.
toR, Nerve to rhomboids.
toS, Nerve to subclavius.
SS, Suprascapular.
EAT, External anterior thoracic.
IAT, Internal anterior thoracic.
S, Subscapular nerves.
C, Circumflex.
IC, Internal cutaneous.
LIC, Lesser internal cutaneous.

the clavi-pectoral fascia blends above with the sheath of the subclavius, and below with the sheath of the pectoralis minor. Four structures perforate the fascia, namely, the cephalic vein, the acromio-thoracic vessels, and the external anterior thoracic nerve.

When the shoulder is abducted the clavi-pectoral fascia is made tense.

Brachial Plexus—The brachical plexus is formed by the anterior primary divisions of the lower four

cervical and first thoracic nerves (Fig. 2). The fifth and sixth cervicals unite as the upper trunk, the seventh becomes the middle trunk, and the eighth cervical and the first thoracic form the lower trunk. Each trunk divides into an anterior and a posterior stem; the anterior divisions of the upper and middle trunks form the outer cord; the anterior division of the lower trunk becomes the inner cord; the posterior divisions of the trunks unite as the posterior cord. Arising from the outer cord are three nerves, (*a*) external anterior thoracic, (*b*) outer head of median, and (*c*) musculo-cutaneous. *All the branches from the outer cord take origin from the fifth, sixth, and seventh cervicals.* Springing from the inner cord are (*a*) the lesser internal cutaneous, (*b*) internal cutaneous, (*c*) internal anterior thoracic, (*d*) inner head of median, and (*e*) ulnar. *All the branches from the inner cord which are of surgical importance arise from the eighth cervical and first thoracic nerves.* Three branches are given off from the posterior cord, (*a*) subscapulars, (*b*) circumflex, and (*c*) musculo-spiral.

Table of Main Branches of Brachial Plexus.

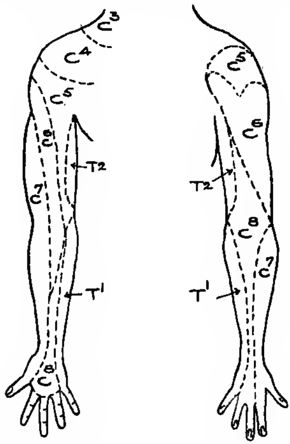
Nerve.	Origin.	Sensory.	Articular.	Motor.
Circum-flex	C v. vi.	Deltoid region of shoulder	Shoulder and acromio-clavicular	Deltoid and teres minor.
Nerve of Bell	C v. vi. vii.	......	......	Serratus anterior.
Musculo-cutaneous	C v. vi. vii.	Outer side of arm from elbow to thenar eminence	Elbow and superior radio-ulnar	Biceps, coraco-brachialis, and part of brachialis (anticus).

Nerve.	Origin.	Sensory.	Articular.	Motor.
Musculo-spiral	C (v.) vi. vii. viii. T i.	Outer side of upper arm from deltoid insertion to elbow, and outer side of back of forearm Radial branch *See* Hand	Elbow and superior radio-ulnar. The posterior interosseous branch supplies — inferior radio-ulnar, radio-carpal, carpal, and the carpo-metacarpal of fingers	Triceps, anconæus, part of brachialis, brachio-radialis, and extensor carpi radialis longus. The posterior interosseous supplies all the muscles on the posterior aspect of the forearm which are not innervated by the musculo-spiral.
Median	C (v.) vi. vii. viii. T i.	*See* Hand	Elbow, radio-carpal, carpal, all joints of thumb, and interphalangeal of digits except little finger. The anterior interosseous supplies the inferior radio-ulnar joint	Superficial flexors on anterior aspect of forearm except the flexor carpi ulnaris; Abductor, opponens, and flexor brevis of thumb; outer two lumbricales. The anterior interosseous supplies the flexor longus pollicis, pronator quadratus, and outer half of flexor profundus digitorum.
Ulnar	C viii. T i.	*See* Hand	Elbow, radio-carpal, carpal, carpo-metacarpal of fingers, metacarpo-phalangeal of fingers and interphalangeal of inner two digits	Flexor carpi ulnaris, inner half of flexor profundus digitorum; inner two lumbricales; all interossei; adductors of thumb; palmaris brevis; abductor, flexor brevis, and opponens of little finger.

Fig. 3, founded on the observations of Head, delimits the cutaneous areas of the upper extremity.

Axillary Vessels.—These vessels lie on the outer side of the axillary space, and accordingly accompany the upper arm in its various movements. The vein lies internal to, and overlaps the artery in the greater part of its course. It is thus more liable to be injured than the artery in operations about the axilla, such

Fig 3.—CUTANEOUS AREAS OF UPPER EXTREMITY. (After HEAD).



a, Palmar aspect. *b*, Dorsal aspect.

as removing cancerous glands. A wound of the axillary vein is dangerous, for not only is the hæmorrhage very profuse, but owing to its close proximity to the heart, air is liable to be drawn into the vein during inspiration. Bleeding from the axillary vessels cannot cease spontaneously, as their sheaths are attached to the clavi-pectoral fascia; this tends to prevent the necessary retraction of the divided vessel.

The axillary artery extends from the outer border of the first rib to the lower border of the teres major

muscle. The surface marking of the artery varies with the position of the limb, for with the arm at right angles to the trunk, a line from the middle of the clavicle to the inner border of the coraco-brachialis will indicate the direction of the vessel, but with the arm adducted the artery takes a curved course, the convexity being directed upwards. For descriptive purposes the artery is divided into three parts—above, behind, and below the pectoralis minor. The main relations are—

First Part

Anterior

Integument and fasciæ.
Pectoralis major.
Clavi-pectoral fascia and the structures piercing it, *i.e.*, cephalic vein, acromio-thoracic vessels, and external anterior thoracic nerve.

Superior and External		*Inferior and Internal*
Brachial plexus.	**A**	Axillary vein.

Posterior

1st intercostal space and intercostal muscles.
Serratus anterior.
Nerve of Bell.
Inner cord of brachial plexus.

Second Part

Anterior

Integument and fasciæ
Pectoralis major and pectoralis minor.

External		*Internal*
Outer cord of brachial plexus.	**A**	Inner cord of brachial plexus. Axillary vein.

Posterior

Posterior cord of brachial plexus.
Subscapularis.

Third Part

Anterior

Pectoralis major.
Integument and fasciæ.
Inner head of median and internal cutaneous nerves.

External		*Internal*
Median and musculo-cutaneous nerves.	**A**	Ulnar and lesser internal cutaneous nerves.
Biceps and coraco-brachialis.		Axillary vein.

Posterior

Musculo-spiral and circumflex nerves.
Subscapularis, latissimus dorsi, and teres major muscles.

Branches of Axillary Artery

1st Part = Superior thoracic—distributed to the first intercostal space.

2nd Part = Acromio-thoracic—to the clavicle, pectoral muscles, and the shoulder.
Lateral thoracic—associated with the nerve of Bell, and is distributed to the side of the thorax and mamma. It gives off the external mammary. Frequently also the alar thoracic springs from the lateral thoracic.

3rd Part = {
Alar thoracic — to axillary fat and glands.
Subscapular — the largest branch of the axillary; it runs along the lower border of the subscapularis, being associated with the subscapular nerve to the latissimus dorsi. The subscapular artery gives off an important branch, the dorsalis scapulæ.
Anterior circumflex — distributed to the deltoid.
Posterior circumflex — passes through the quadrilateral space with the circumflex nerve; it supplies the deltoid.

The axillary artery is occasionally the seat of aneurysm, due chiefly to its close proximity to the shoulder-joint, which causes it to be subjected to frequent and extensive movements. Statistics show that axillary aneurysm is more commonly met with on the right side and amongst men. The artery may be injured by falls on the outstretched hand, and many cases have been recorded of rupture of the vessel by the forcible reduction of old-standing dislocations of the shoulder, the artery in these cases having probably contracted adhesions to the joint.

Ligature of the axillary artery may be performed in its first or third parts. The first part of the artery is so deeply placed and is in such close relation to the vein and to the cords of the brachial plexus, that its ligature is rarely undertaken, the third part of the subclavian being preferred. In tying the third part an incision is made along the inner border of the coraco-brachialis. After division of the superficial structures, the coraco-brachialis is retracted outwards and the inner head of the median nerve defined. It also is displaced to the outer side. The aneurysm needle is passed from within outwards *i.e.* from the axillary vein and the ulnar nerve. If possible the artery should be ligated above the sub-scapular branch in order to get the benefit of the anastomosis around the scapula (see page 16.)

Lymphatic Glands—There are five groups of lymphatic glands in the axilla; they freely communicate with each other.

The axillary group are in close apposition to the axillary vein, and receive the lymphatics from the greater part of the upper extremity, and also the retro-mammary lymphatics; they are liable to become enlarged and inflamed through septic absorption from wounds of the upper extremity, and to be involved in malignant disease of the breast.

The pectoral set accompany the lateral thoracic vessels and lie near the lower border of the pectoralis minor; they drain the lymphatics from the breast and thoracic wall. In mammary carcinoma they may be felt as an indurated knotted cord.

The subscapular set accompany the artery of the same name, receiving lymphatics from the back and a few from the breast. Enlargement of these glands often occurs from bedsores around the scapular region.

The central glands of Leaf are situated either (*a*)

superficial to the axillary fascia, or (*b*) in a pocket formed by the fascia, or (*c*) more rarely, are placed upon the deep surface of the fascia, and thus come to be associated with the subscapular group. Some of the mammary lymphatics terminate in these nodes. All the axillary glands ultimately drain into the sub-clavicular glands, which are six to ten in number, and are found at the apex of the axilla; their efferents unite to form the subclavian lymph trunk.

Infraclavicular Glands—These comprise (*a*) the gland in the delto-pectoral furrow which drains the outer side of the arm and the shoulder, and (*b*) two or three small glands lying upon the clavi-pectoral fascia; they are frequently affected in mammary carcinoma.

THE CLAVICLE.

The clavicle is subcutaneous throughout and can be easily traced in its whole extent. Superficial to the bone are the skin, fasciæ. and platysma, and the descending branches of the third and fourth cervical nerves; these nerves may be involved in callus after fracture of the bone and be the source of great pain. The integument over the clavicle is very elastic and mobile, hence the rarity of compound fractures in this situation.

Beneath the clavicle are several important structures, of which may be mentioned the subclavian and supra-scapular arteries, the subclavian, external jugular, and innominate veins, and the nerve trunks of the brachial plexus. Any of these vessels or nerves may be torn or compressed by broken fragments of the bone. The subclavian vein lying in the small angular interval between the inner end of the clavicle and the first rib is the vessel most exposed to injury.

The close proximity of these important structures renders partial, or complete resection of the bone an operation of great difficulty.

Excepting the radius, the clavicle is more commonly the seat of fracture than any other bone in the body. This is not only due to its exposed position, and its slenderness, but also to it forming the only osseous connection between the upper extremity and the trunk; the clavicle therefore receives a part of all shocks given to the upper extremity by falls on the hand, elbow, or shoulder. In spite of its superficial position the clavicle is not very commonly fractured by direct violence. When such a fracture occurs, it may take place at any part of the bone.

In fractures from indirect violence the break most commonly occurs at the junction of the outer and middle thirds, because (*a*) here the two curves of the bone meet; (*b*) it is the most fragile portion of the bone; and (*c*) the outer third, which is practically fixed, joins a movable portion. In this fracture, which is usually very oblique, the outer fragment is displaced downwards by the weight of the arm; inwards, because the clavicle normally keeps the shoulder away from the chest, acting like an outrigger; and forwards, owing mainly to the action of the pectoral muscles. The inner fragment is slightly tilted upwards by the sterno-mastoid; it cannot, however, move far, as it is anchored to the first rib and its cartilage by the subclavius muscle and the costo-clavicular (rhomboid) ligament.

Sterno-clavicular Articulation.—This is a diarthrodial joint formed by the clavicle, manubrium sterni, and the upper surface of the first costal cartilage. The joint is not osseously strong, for the sternal extremity of the clavicle is large while the clavicular facet of the sternum is small and shallow. In spite of this, however,

dislocations of the articulation are less common than those of the acromio-clavicular joint, owing to the great strength of the ligaments. Three varieties of dislocation may occur—forwards, backwards, and upwards, the first being the most frequent. When the clavicle is dislocated backwards, pressure may be exercised upon the trachea, the large veins at the root of the neck, or even the œsophagus. Before an upward dislocation can occur the costo-clavicular ligament must be torn.

The ligaments are (*a*) the capsule, with anterior, posterior, and superior sterno-clavicular bands; (*b*) a fibro-cartilaginous meniscus; (*c*) the inter-clavicular; and (*d*) the costo-clavicular. Two synovial membranes are present; they are separated from each other by the meniscus.

Movements—

(i.) Elevation of shoulder	Sterno-mastoid, levator angulæ scapulæ. Trapezius (upper fibres), omo-hyoid, aud rhomboidei.
(ii.) Depression of shoulder	Weight of arm, subclavius, trapezius (lower fibres), pectoralis minor, and latissimus dorsi.
(iii) Shoulder forwards	Pectoralis minor and serratus anterior.
(iv.) Shoulder backwards	Trapezius, rhomboidei, and latissimus dorsi.

THE SCAPULA.

The scapula covers the posterior aspect of the thorax from the second to the seventh or eighth ribs. It is well covered by muscles, and is attached to the trunk by the serratus anterior, levator anguli scapulæ, rhomboidei, trapezius, omo-hyoid, and frequently the latissimus dorsi.

Normally, the inferior angle of the scapula is covered by the latissimus dorsi. This muscle occasionally slips away from the bone and becomes hooked beneath it.

Fractures of the Scapula.—The scapula may be broken in one of several places—(i.) the coracoid or acromion processes may be fractured or their epiphyses separated; (ii.) the bone may give way through its surgical neck—*i.e.*, through the narrow part extending around the glenoid cavity and into the suprascapular notch; or (iii.) the fracture may occur through the infraspinous fossa. As the coracoid process is firmly attached to the clavicle and acromion by ligaments, great displacement cannot occur in this variety unless the ligaments be ruptured.

Fracture of the surgical neck may be mistaken for a dislocation of the shoulder-joint; when the bone is broken, however, the coracoid process moves on rotating the arm.

Anastomosis around the Scapula.—This important anastomosis is formed by three arteries—(*a*) suprascapular, from the thyroid axis, a branch of the first part of the subclavian; (*b*) posterior scapular, from the transversalis colli, a branch of the thyroid axis; and (*c*) dorsalis scapulæ of the subscapular, a branch of the third part of the axillary.

In excision of the scapula remember that the suprascapular artery and nerve are found in relation to the

upper border of the bone, the posterior scapular artery and the nerve to the rhomboids, to the vertebral border, and the dorsalis scapulæ and subscapular arteries along the axillary border.

Ligaments of the Scapula.—In addition to the ligaments of the acromio-clavicular articulation, the scapula is united to the clavicle by the coraco-clavicular ligament. This comprises two bands, conoid and trapezoid, the two being separated by a small bursa. The proper scapular ligaments are four in number, the glenoid, the coraco-acromial, the transverse, and the spino-glenoid, the great scapular notch being spanned by the latter ligament. The spino-glenoid ligament protects the suprascapular artery and nerve as they pass from the supraspinous to the infraspinous fossa.

Acromio-Clavicular Articulation.—The bony surfaces forming this joint are oblique; the plane of the joint corresponding to a line drawn downwards and inwards. This direction of the joint explains the greater frequency of dislocation of the clavicle in an *upward* direction. As the capsular ligament is weak, the strength of the joint depends mainly on the coraco-clavicular ligaments.

SHOULDER-JOINT.

This is an enarthrosis or ball-and-socket joint, the stability of which mainly depends upon its muscles.

The head of the humerus is very large compared with the glenoid cavity with which it articulates; the capsular ligament is lax, and allows the humerus to be drawn away some distance from its socket. For these reasons the joint is very insecure and liable to be dislocated. The tendon of the biceps arches over the head of the humerus, and assists the other muscles in

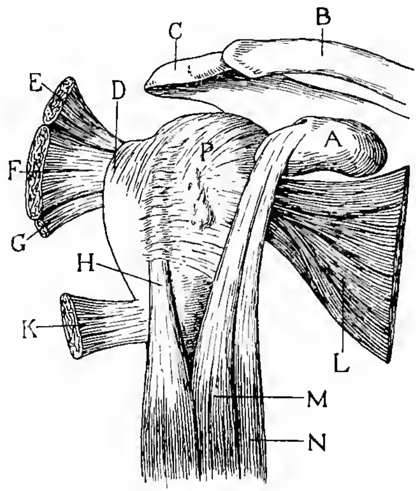
keeping this bone in close contact with the glenoid cavity.

The articulation is protected above by an overhanging arch, formed by the acromion and coracoid processes and the coraco-acromial ligament. Separating the capsule from this arch is the *sub-acromial bursa*, an extension upwards of the sub-deltoid bursa. This bursa may become inflamed or distended; in such cases abduction of the arm causes great pain, owing to the bursa being compressed between the great tuberosity of the humerus and the acromion process. The capsule is pierced by the biceps tendon which carries a tubular investment of synovial membrane—the intertubercular bursa, for a distance of about two inches down the bicipital groove. An opening exists in the capsule, through which the joint cavity communicates with a bursa beneath the subscapularis. The orifice will usually be found on the anterior aspect of the joint. If suppuration occur in the joint, the pus is likely to escape through one of the above apertures. In addition to the capsule and the tendon of the biceps, the shoulder-joint possesses the glenoid, gleno-humeral, transverse humeral, and coraco-humeral ligaments. The capsule is attached above to the margin of the glenoid fossa, partly blending with the glenoid ligament; below it terminates round the anatomical neck of the humerus. Remember the position of the transverse humeral band. It stretches across the bicipital groove from the greater to the lesser tuberosity. During arthrectomy of the shoulder-joint, this ligament is early divided, in order that the biceps tendon may be dislodged from the groove and protected from injury. The coraco-humeral and gleno-humeral ligaments are accessory bands strengthening the capsule.

Dislocations of the shoulder are all primarily in a

downward, direction—*sub-glenoid;* afterwards depending upon the direction of the force, and the position of the limb at the time of injury, the head of the humerus may travel forwards—*sub-coracoid* or *sub-clavicular*, or backwards—*sub-acromial* or *sub-spinous.* Notice that the capsule is protected above by the coraco-acromial arch

Fig. 4.—THE SHOULDER-JOINT.



A. Coracoid Process.
B. Clavicle.
C. Acromion Process.
D. Greater Tuberosity of Humerus.
E. Supraspinatus.
F. Infraspinatus.
G. Teres Minor.
H. Long Head of Biceps.
K. Pectoralis Major.
L. Subscapularis.
M. Short Head of Biceps.
N. Coraco-brachialis.
P. Capsular Ligament.

and the supraspinatus; in front by the subscapularis; and behind by the infraspinatus and teres minor.

Movements—

(i.) Flexion of arm { Deltoid (anterior fibres), subscapularis, pectoralis major, biceps, and coraco-brachialis.

(ii.) Extension of arm . .	Deltoid (posterior fibres), teres major, triceps, and latissimus dorsi.
(iii.) Abduction of arm . .	Deltoid and supraspinatus.
(iv.) Adduction of arm . .	Teres muscles, pectoralis major, latissimus dorsi, and coraco-brachialis.
(v.) External rotation of arm .	Deltoid (posterior fibres), infraspinatus, and teres minor.
(vi.) Internal rotation of arm .	Deltoid (anterior fibres), teres major, pectoralis major, and latissimus dorsi.
(vii.) Circumduction	A combination of the above muscles.

Arterial Supply.—The anterior and posterior circumflex and suprascapular arteries.

Nerve Supply.—The circumflex and suprascapular nerves.

Table of Chief Attachments and Nerve Supply of Muscles acting on the Shoulder-Joint.

Muscle.	Origin.	Insertion.	Nerve Supply.
Subscapularis	Subscapular fossa on venter of scapula	Lesser tuberosity of humerus	Short subscapular
Supraspinatus	Supraspinous fossa on dorsum of scapula	Upper facet on great tuberosity of humerus	Suprascapular
Infraspinatus	Infraspinous fossa on dorsum of scapula	Middle facet on great tuberosity of humerus	Suprascapular

Muscle.	Origin.	Insertion.	Nerve Supply.
Teres major	Lower third of axillary margin of scapula	Inner bicipital ridge of humerus	Middle subscapular
Teres minor	Upper two-thirds of axillary margin of scapula	Lower facet on great tuberosity of humerus	Circumflex
Deltoid	Anterior aspect of clavicle in its outer third, lower border of scapular spine, and outer border of acromion process	Deltoid eminence of humerus	Circumflex
Biceps	Long head from supra-glenoid tubercle of scapula; short head from coracoid process	Bicipital tubercle of radius	Musculo-cutaneous
Triceps	Long or middle head from infra-glenoid tubercle of scapula; outer and inner heads from posterior aspect of shaft of humerus.	Olecranon process of ulna	Musculo-spiral
Coraco-brachialis	Coracoid process	Middle of inner aspect of shaft of humerus	Musculo-cutaneous
Pectoralis major	Anterior aspect of clavicle in its inner two-thirds, outer margin of sternum, and upper six costal cartilages	Outer bicipital ridge of humerus	External and internal anterior thoracic
Latissimus dorsi	Lower six dorsal spines, lumbar spines through the lumbar fascia; posterior third of outer lip of iliac crest; lower three ribs, and often from inferior angle of scapula	Floor of bicipital groove of humerus	Long subscapular

THE UPPER ARM

Surface Anatomy.—On the front of the upper arm the biceps forms a well-marked prominence, which can be traced down to the front of the elbow. On each side of the muscle is a shallow depression—*the inner and outer bicipital sulci.* In the outer groove the cephalic vein passes upwards, while the inner furrow contains the brachial artery, the basilic vein, the median nerve, and also, in the upper half, the ulnar nerve.

The insertion of the deltoid can be felt, for here the humerus is almost superficial, although it is covered by muscles in the greater part of its extent.

The insertion of the deltoid is an important landmark in the upper arm—(*a*) it is near the middle of the bone; (*b*) on the inner side is the insertion of the coraco-brachialis; (*c*) the medullary artery enters the humerus at this level; (*d*) it marks the upper limit of the brachialis muscle; (*e*) at this point the ulnar nerve and superior ulnar collateral (inferior profunda) artery leave the inner side of the brachial artery to pass obliquely to the interval between the internal epicondyle and the olecranon process; and (*f*) the median nerve crosses in front of the brachial artery.

The *aponeurosis of the upper arm* forms a loose sheath for the muscles, vessels, and nerves. It is attached laterally to the humerus by means of the internal and external intermuscular septa, which thus form two compartments.

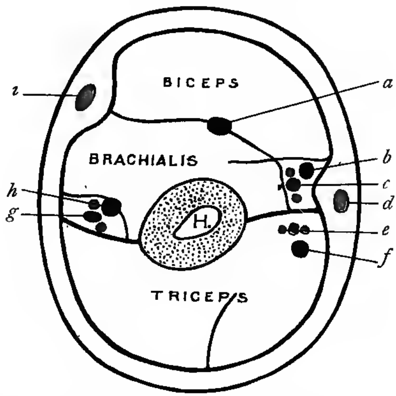
In the *anterior compartment* will be found the biceps, coraco-brachialis, and brachialis muscles; the brachial vessels; the median, ulnar, internal cutaneous and musculo-cutaneous nerves.

The *posterior compartment* contains the triceps, with

the musculo-spiral nerve and profunda (superior profunda) artery in a part of their course.

Brachial Artery.—The brachial artery commences at the lower border of the teres major muscle and terminates opposite the neck of the radius by dividing into the radial and the ulnar. On the surface of the body, the course of the artery can be marked out by a

Fig. 5.—TRANSVERSE SECTION MIDDLE OF RIGHT UPPER ARM.



a, Musculo-cutaneous nerve.
b, Median nerve.
c, Brachial artery.
d, Basilic vein.
e, Inferior profunda vessels.
f, Ulnar nerve.
g, Superior profunda vessels.
h, Musculo-spiral nerve.
i. Cephalic vein.

line drawn from the centre of the clavicle to the middle of the bend of the elbow, or more simply, by the internal bicipital sulcus.

It must be borne in mind that the brachial artery frequently divides at a higher level than the neck of the radius ; such a high bifurcation may prove troublesome when ligating the brachial for palmar hæmorrhage.

Relations :—

Anterior

Integument and fasciæ.
Median basilic vein and bicipital fascia.
Median nerve.
Biceps.

External		*Internal*
Median nerve (above). Coraco-brachialis. Biceps.	**A**	Ulnar and internal cutaneous nerves. Median nerve (below). Basilic vein.

Posterior

Triceps (long and inner heads).
Musculo-spiral nerve.
Profunda (superior) artery.
Coraco-brachialis.
Brachialis.

The median nerve crosses the brachial artery from without inwards, opposite the insertion of the coraco-brachialis. In exceptional cases the nerve passes behind the artery.

For the greater part of its course the artery is accompanied by three veins—two venæ comites and the basilic vein.

The branches of the brachial artery are—muscular, profunda, superior ulnar collateral, medullary to the humerus, and inferior ulnar collateral (anastomotica magna). The profunda gives off an ascending branch to anastomose with the descending branch of the posterior circumflex.

Ligature of Brachial Artery.—The artery is reached by an incision along the inner border of the

biceps muscle, and from the close relation of the median nerve to the artery, it will be seen that great care is necessary when passing the needle in ligature of the vessel. It is well to remember that a small process of bone, the supra-condyloid process, occasionally projects from the inner aspect of the humerus above the inner epicondyle, and when such a process exists, the brachial artery passes behind it before the vessel reaches the front of the elbow. In this deviated course it is accompanied by the median nerve.

Musculo-spiral Nerve.—The musculo-spiral nerve is derived from the posterior cord of the brachial plexus (C.V., VI., VII., VIII. and T.I.), and passes down behind the third part of the axillary and the upper part of the brachial artery. It enters the musculo-spiral groove accompanied by the profunda branch of the brachial, between the long and inner heads of the triceps. In the groove it lies under cover of the outer head of the triceps. About 2½ inches above the external epicondyle the nerve pierces the external intermuscular septum, and then appears between the brachio-radialis and the brachialis muscles. At the elbow, the musculo-spiral divides into the radial and the posterior interosseous.

Fractures of the shaft of the humerus may be followed by paralysis of the muscles supplied by the musculo-spiral nerve, and its posterior interosseous branch. This may occur at the time of accident, the nerve being injured by one of the sharp fragments of the bone, or at a later period when the nerve becomes included in, or compressed by, the callus which is formed between the broken ends.

The paralysis which follows injury to the musculo-spiral nerve affects the muscles on the back of the forearm, and renders extension of the wrist impossible

(drop wrist). There remains, however, a slight power of extending the fingers though their main extensor muscles are paralysed, as the second and third phalanges are extended by the interossei and lumbrical muscles. The power of supination is also greatly diminished, owing to paralysis of the brachio-radialis and supinator brevis muscles; it is not entirely lost, as the action of the biceps remains unaltered. It is interesting to notice that the triceps and brachialis, though supplied by the musculo-spiral nerve, are not paralysed, as the former is mainly supplied by branches which are given off from the musculo-spiral before it comes into contact with the humerus, and the latter has an additional nerve from the musculo-cutaneous.

The musculo-spiral may be paralysed by the pressure of the pad of a crutch (crutch palsy); this condition cuts off the motor supply to the triceps, hence the elbow is flexed.

Fracture of the external condyle may cause paralysis of the *posterior interosseous nerve.* In such a case, the loss of supination and extension is not so complete as when the whole trunk is paralysed, these movements being still practicable, to a slight extent, through the medium of the brachio-radialis and extensor carpi radialis longus, which are supplied by the trunk of the musculo-spiral nerve.

Musculo-cutaneous Nerve.—A continuation of the outer cord (CV., VI., and VII.) of the brachial plexus, the nerve pierces the coraco-brachialis to pass down between the biceps and the brachialis muscles. It becomes superficial at the antecubital fossa, and from thence forms the lateral cutaneous nerve of the forearm. It terminates in the skin of the thenar eminence of the hand. Three muscles are supplied by it, namely—the biceps, coraco-brachialis, and the brachialis.

Fractures of the Humerus.—If the *surgical neck* be fractured obliquely, the upper fragment is abducted by the supraspinatus, and slightly rotated out by the muscles attached to the great tuberosity, while the lower fragment is drawn upwards and inwards by the muscles inserted into the bicipital groove—pectoralis major, teres major, and latissimus dorsi. The circumflex nerve may be injured, leading to paralysis of the deltoid.

The displacements due to *fractures of the shaft* vary.

When *above the insertion of the deltoid*, the upper fragment is drawn inwards by the muscles attached to the bicipital groove, and the lower fragment upwards and outwards by the deltoid.

When *below the insertion of the deltoid*, the upper fragment is tilted outwards by that muscle, and the lower fragment is pulled upwards by the biceps and triceps.

In *transverse fractures above the epicondyles*, the lower fragment and the forearm are drawn upwards and backwards by the triceps, so that the injury simulates a backward dislocation of the elbow. The T-shaped fracture, and fractures of the condyles, involve the elbow-joint, but the internal epicondyle may be broken off without injuring the joint. In the last variety the ulnar nerve is often damaged, thus causing the "main-en-griffe" deformity.

REGION OF THE ELBOW.

Surface Anatomy.—The bony points in the region of the elbow should be carefully studied. Feel first the olecranon process, to which the tendon of the triceps can be traced. On the inner and outer aspects of the elbow, the internal and external epicondyles of the

humerus are easily distinguished; the internal is the more marked and pointed, and forms an extremely definite and important bony landmark. Remember that it points in the same direction as the head of the humerus.

If a line be drawn between the epicondyles, it will be found that in extreme extension the tip of the olecranon lies a little above that line.

If the forearm be placed at right angles to the arm, the tip of the olecranon lies below the epicondyles and in the same vertical plane; while in full flexion, the olecranon lies in front of that plane.

Just external to the olecranon process is a small dimple when the forearm is extended. This depression corresponds to the head of the radius and the external epicondyle. The head of the radius may be felt on alternately pronating and supinating the forearm.

Notice especially that the internal epicondyle is prominent in flexion and extension. But the external epicondyle, which forms a marked swelling in the flexed position, disappears completely out of view in the extended position, and lies in the hollow on the outer side of the olecranon previously referred to.

It is very necessary that the student should make himself familiar with the position and relations of these bony eminences, as the diagnosis of injuries to the elbow region is thereby considerably facilitated.

Olecranon Bursa.—Over the olecranon lies a large subcutaneous bursa, which may become enlarged or inflamed, as in *miner's elbow*. A small bursa also lies beneath the tendon of the triceps, close to its insertion.

Along the groove between the internal epicondyle and olecranon, the ulnar nerve enters the forearm; its position has to be borne in mind in excision of the

elbow-joint, and it is exposed to injury in fracture of the internal epicondyle.

At the depressions on each side of the olecranon the synovial membrane closely approaches the surface; in synovitis they are obliterated by the bulging of the distended or thickened membrane.

Antecubital Fossa.—On the front of the elbow is a small depression, termed the antecubital fossa. It is bounded externally by the brachio-radialis and on the inner side by the pronator teres. The base is formed by an imaginary line joining the epicondyles.

Into this hollow the tendon of the biceps may be traced, and passing from the tendon to the inner group of muscles is the bicipital or semilunar fascia; it is rendered prominent during flexion and supination of the forearm. On the inner side of the tendon of the biceps, and above the free border of the bicipital fascia, the pulsations of the brachial artery can be felt.

At the bend of the elbow a slight crease or line extends across between the two epicondyles. The joint line lies below this crease, and it is said to be of use in diagnosing a backward dislocation of the bones of the forearm from a transverse supracondylar fracture of the lower end of the humerus; for in the dislocation, the lower extremity of the humerus projects forwards *below* this line, while in the fracture, the lower end of the upper fragment projects *above* this line.

Veins in front of the Elbow.—In the forearm are the median, the cephalic (radial), and the basilic (ulnar) veins.

Near the elbow the median vein receives the profunda vein (which is formed by the junction of the venæ comites of the anterior and posterior interosseous arteries), and then divides into the median-cephalic and median-basilic veins.

The median-basilic joins the basilic vein, which, at the lower border of the teres major, becomes the axillary.

The median-cephalic runs into the cephalic vein. This passes up on the outer side of the biceps, and then between the deltoid and pectoralis major, to pierce the clavi-pectoral fascia and open into the axillary.

The median-basilic is the vein usually selected by the surgeon for saline transfusion. It lies over the brachial artery, being separated from that vessel merely by the bicipital fascia, and care should be taken not to pass the knife in too deeply, lest the fascia be pierced and the artery wounded.

About $1\frac{1}{2}$ inches above the internal epicondyle the epitrochlear *lymphatic gland* is found. It receives the lymphatics of the inner side of the forearm, and its efferent ducts follow the basilic vein. This gland may become inflamed from the absorption of some pyogenic organisms conveyed along the lymphatics, or enlarged during the secondary stage of syphilis; it is important as being the lowest gland of appreciable size in the upper extremity.

Anastomosis around the Elbow-Joint.—A very free anastomosis occurs in the region of the elbow. The most important arteries which share in this anastomosis are the profunda, with the radial recurrent and interosseous recurrent arteries, in front of, and behind the external epicondyle—and the superior ulnar collateral (inferior profunda), and inferior ulnar collateral (anastomotica magna), with the anterior and posterior ulnar recurrent arteries in front of, and behind, the internal epicondyle.

ELBOW-JOINT.

Along with the elbow it is convenient to study the superior radio-ulnar joint. The former is a hinge-joint (ginglymus), while the latter forms a pivot joint (trochoides). The trochlea, or internal condyle, of the humerus articulates with the incisura semilunaris (greater sigmoid cavity) of the ulna; and the capitellum, or external condyle, with the fovea capitula of the radius. In the superior radio-ulnar joint the articular circumference of the head of the radius fits into the incisura radialis (lesser sigmoid cavity) of the ulna.

The Ligaments are—capsular, ulnar collateral (internal lateral), radial collateral (external lateral), annular (orbicular), oblique, and the interosseous membrane.

Superiorly, the capsule is attached to the humerus; inferiorly, to the ulna and the annular ligament of the radius. The anterior part extends from just above the coronoid fossa to the coronoid process and annular ligament, while the posterior part stretches from the upper margin of the olecranon fossa to the olecranon process and annular ligament. Notice that the capsule is much stronger anteriorly than posteriorly. The attachments of the remaining important ligaments of the joint are:—

Radial Collateral—from the external epicondyle to the olecranon and annular ligament.

Ulnar Collateral—from the internal epicondyle to the coronoid and olecranon processes.

Annular—this ligament forms about four-fifths of a circle, and is attached to the anterior and posterior margins of the incisura radialis. It is narrower below than above. In young children the head of the radius may be dislodged from the ligament, a condition known as "pulled elbow."

The Synovial Membrane lines the connecting ligaments, covers the soft fatty pads which occupy the fossæ of the humerus, and is prolonged downwards to become continuous with the synovial membrane of the superior radio-ulnar joint.

Arterial Supply.—Branches from the brachial, ulnar, radial, and posterior interosseous arteries.

Nerve Supply.—Twigs from the ulnar, median, musculo-spiral, and musculo-cutaneous nerves.

Table of the Chief Muscles acting on the Elbow-Joint.

FLEXORS.	EXTENSORS.
Brachialis. Biceps. Brachio-radialis. Pronator teres. Flexors attached to internal epicondyle.	Triceps. Anconæus. Extensors attached to external epicondyle.

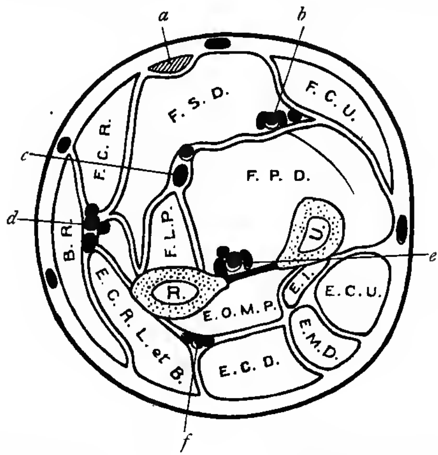
THE FOREARM.

Blood-vessels of the Forearm.—In the volar section of the forearm are the ulnar, radial, and anterior interosseous arteries. This last vessel courses downwards on the anterior surface of the interosseous membrane lying between the flexor longus pollicis and the flexor profundus digitorum. It passes to the back of the forearm by dipping beneath the pronator quadratus. In addition to providing the medullary arteries for the radius and ulna, the anterior interosseous gives off the comes nervi mediani; occasionally this vessel is of so remarkable a size as to provide the phenomenon of "double pulse." Such a condition indicates the persistence of the primary main artery of the forearm.

The loose integument behind the elbow-joint is extremely vascular, but with this exception, the posterior aspect of the forearm is remarkably free from vessels and nerves—this being the part most exposed to injury. On this surface we find the small posterior interosseous vessels and nerve, which travel downwards between the superficial and deep strata of muscles.

Radial Artery.—The radial artery takes a straight

Fig. 6.—Transverse Section through Right Forearm.



a, Palmaris longus. *b*, Ulnar vessels and nerve.
c, Median nerve and artery. *d*, Radial vessels and nerve.
e, Anterior interosseous vessels and nerves. *f*, Posterior interosseous vessels.

course from a spot a finger's-breath below the centre of the bend of the elbow, to a point midway between the tendon of the flexor carpi radialis and the styloid process of the radius. In its upper half it is covered by the brachio-radialis, but is superficial in its lower half.

The upper third of the artery lies between the brachio-radialis and the pronator teres, and in its lower two-thirds between the brachio-radialis and the flexor

carpi radialis. The radial nerve is closely applied to the outer side of the vessel in its middle third. The artery may be readily reached in its lower third where it is superficial. In its upper two-thirds it is found beneath the inner border of the brachio-radialis.

The following branches spring from the radial artery:—

(*a*) *In forearm*—The radial recurrent, muscular, superficialis volæ, and anterior carpal.

(*b*) *At wrist*—The dorsales pollicis, dorsalis indicis, posterior carpal, and metacarpal.

(*c*) *In hand*—The princeps pollicis and radialis indicis.

Ulnar Artery.—A line drawn from the internal epicondyle to the outer border of the pisiform bone indicates the direction of the ulnar artery, and the vessel corresponds, in its lower two-thirds, to this line. The upper third of the artery takes a curved course from the bifurcation of the brachial to the above line. In its upper part the ulnar lies deeply beneath the pronator teres and the group of flexor muscles which arise from the internal epicondyle. In its lower part it is superficial, and is found between the flexor sublimis digitorum and the flexor carpi ulnaris; and may be easily reached in this position by an incision on the outer border of the flexor carpi ulnaris. The ulnar nerve lies close to its inner side in its lower two-thirds, and the vessel is crossed by the median nerve near to its origin, the deep head of the pronator teres, however, intervening between the two structures.

A great many branches arise from the ulnar artery. They are:—

(*a*) *In forearm*—The anterior and posterior ulnar recurrent; the common interosseous dividing into anterior and posterior interosseous.

(*b*) *At wrist*—The anterior and posterior carpal.

(*c*) *In hand*—The profunda.

Median Nerve.—After leaving the antecubital fossa, the median nerve lies between the two heads of the pronator teres. It then passes beneath the superficial flexor muscles, to appear at the wrist a little to the ulnar side of the flexor carpi radialis, almost midway between the two styloid processes. The anterior interosseous branch arises just below the level of the antecubital fossa. With the exception of the flexor carpi ulnaris, all the superficial flexor muscles in the forearm are supplied by the median, and all the deep flexors, except the inner half of the flexor profundus digitorum, by the anterior interosseous.

Ulnar Nerve.—The ulnar nerve occupies the interval between the internal epicondyle and the olecranon process of the ulna, and enters the forearm by passing through the two heads of the flexor carpi ulnaris. It reaches the inner side of the ulnar artery, and is continued downwards on the ulnar border of that vessel to the hand. Two inches above the wrist the dorsal cutaneous branch is given off.

It is important to bear in mind the close relation of the ulnar nerve to the internal epicondyle, as it is liable to be injured in fractures of this region, and has to be avoided in excision of the elbow-joint.

Fractures of the Bones of the Forearm.—Of the shafts of the bones, that of the ulna is subcutaneous throughout on its posterior aspect; and for this reason the dorsal surface of the limb is chosen for operations on this bone. The radius is covered by muscles in its upper half, but the lower half may be traced beneath the skin.

The articulation of the wrist is formed almost entirely by the radius and the carpal bones, and all shocks

transmitted from the hand pass into the radius ; accordingly the radius is usually fractured by indirect violence, while fractures of the shaft of the ulna are caused by direct violence.

Fractures of the Ulna.—In *fracture through the base of the olecranon* the detached fragment is drawn upwards by the triceps.

Fracture of the coronoid process may cause, or complicate, a dislocation of the ulna backwards ; the process is pulled upwards and forwards by the brachialis muscle.

In *fractures of the shaft* of the ulna, the upper fragment tends to be tilted forwards by the brachialis, and the lower fragment approximated to the radius by the pronator quadratus.

Fractures of the Shaft of the Radius.—If this bone be fractured between the attachments of the biceps and pronator teres, the upper fragment is flexed by the biceps and supinated by the same muscle and by the supinator brevis. The lower fragment is pronated by the pronator teres and pronator quadratus, and is drawn towards the ulna by the latter muscle.

If the shaft breaks between the two pronators, the upper fragment is slightly flexed, but neither pronation nor supination occurs, as the supinators (biceps and supinator brevis) are antagonised by the pronator teres.

Colles' Fracture.—In this fracture which occurs through the lower extremity of the radius, the lower fragment is displaced backwards, carrying the hand with it. The fragment is also displaced outwards, and the hand is approximated to the radial border of the forearm. In addition, rotation occurs by which the inferior articular surface of the radius is directed slightly backwards instead of directly downwards. A somewhat

similar injury, though at a slightly higher level, may result from the back-firing of the engine of a motor car—*chauffeur's fracture.*

In treating fractures of the bones of the forearm, it is very necessary to prevent the interosseous space being encroached upon by the broken ends; for if the bones be compressed they become united by the projection of the callus across the interosseous space; pronation and supination are thus lost, and the utility of the limb greatly impaired. The interosseous space is widest when the forearm is in a position midway between pronation and supination.

THE WRIST AND HAND.

Surface Anatomy.—On the anterior surface of the wrist are seen three horizontal creases in the skin: the highest indicates the position of the styloid process of the ulna: the intermediate crease is on a level with the wrist-joint, whilst the lowest of these marks the upper limit of the anterior annular ligament. Immediately above its outer extremity the lower end of the radius may be felt. This bone presents externally a tubercle, to which the tendon of the brachio-radialis is attached. Further inwards the tendon of the flexor carpi radialis can be palpated, and between it and the above tubercle the pulsations of the radial artery are distinguishable. About the middle of the anterior aspect of the wrist the palmaris longus (when present) passes down to be inserted into the palmar fascia; it is rendered very prominent by flexing the wrist. The median nerve lies between the tendons of the palmaris longus and the flexor carpi radialis. The tendon of the flexor carpi ulnaris is easily demonstrated as it passes down to the pisiform bone. Between this tendon and

the flexor sublimis the ulnar vessels and nerve are placed.

The Palm of the Hand and Fingers.—The hollow of the palm is bounded by the thenar and hypothenar eminences, formed by the short muscles of the thumb and little finger respectively.

The palm presents several creases, two of which run almost transversely, while one or more are oblique. The most distal of the transverse lines results from the flexion of the metacarpo-phalangeal articulations—these joints lying midway between this line and the clefts of the fingers—and so corresponds to the upper limit of the digital synovial sheaths. The ulnar end of the superior transverse crease represents the level of the superficial palmar arch.

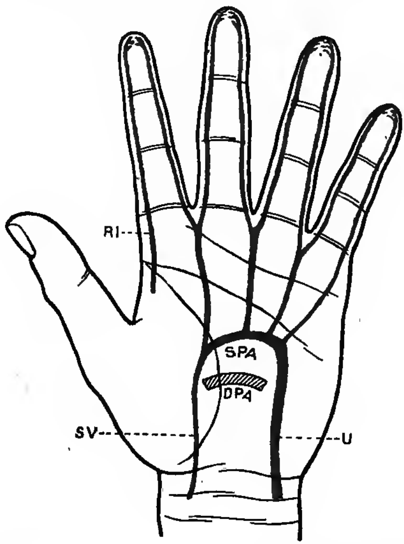
On the fingers there are three well-marked transverse grooves. The upper one lies opposite the web of the fingers, and is half an inch below the metacarpo-phalangeal joint; the middle one is opposite the first interphalangeal joint, while the lower crease is slightly above the second interphalangeal joint. Notice that the web of the fingers projects further downwards anteriorly than posteriorly; so that, while the anterior part of the cleft is half an inch below the metacarpo-phalangeal joint, posteriorly it lies nearly opposite the joint—a fact of some importance in amputations.

Arteries of the Hand.—The *superficial palmar arch* extends from the pisiform bone in a curved direction across the palm, the lower part of the curve corresponding to a line drawn from the thumb when at right angles to the hand. In this situation, the arch lies immediately beneath the palmar fascia upon the flexor tendons and branches of the median nerve. The superficial arch is formed mainly by the ulnar, and is completed by the superficialis volæ or radialis indicis

branches of the radial artery ; from it the digital arteries are given off, which pass to the clefts of the fingers, and there divide into two to supply the adjacent surfaces of the fingers. The branch to the ulnar side of the little finger crosses the palm obliquely. (Fig. 7).

The digital arteries are united by a palmar anastomosing meshwork across the tip of each terminal

Fig. 7.—ARTERIES OF PALM OF HAND.



RI, Radialis Indicis.
U, Ulnar.
SV, Superficialis Volæ.
SPA, Superficial Palmar Arch.
DPA, Deep Palmar Arch.

phalanx. Remember that the digital vessels and nerves lie nearer the palmar than the dorsal aspect of the fingers.

In making *incisions in the palm* of the hand, it is well to remember that the *safe areas* are—*beyond* the line of the superficial palmar arch, and *opposite* the fingers

except the little one, thus avoiding the palmar arch and its digital branches.

The *deep palmar arch* is about a finger's-breadth nearer the wrist than the superficial arch, and lies on the bases of the metacarpal bones and interossei muscles, beneath the flexor tendons. It is formed by the radial artery and the profunda branch of the ulnar.

Radial Artery at the Wrist and Back of the Hand.—From the front of the wrist the radial artery winds below the styloid process of the radius, and beneath the extensor muscles of the thumb. It rests upon the radial collateral ligament, the navicular and trapezium, and reaches the posterior extremity of the first interosseous space, where it passes between the heads of the first dorsal interosseous muscle to enter the palm of the hand.

Branches.—(*a*) The dorsal carpal; this unites with a corresponding branch of the ulnar to form an arch beneath the extensor tendons. From this arch two metacarpal arteries arise, which are distributed to the third and fourth inter-metacarpal spaces.

(*b*) The dorsal metacarpal; it occupies the second inter-metacarpal space.

(*c*) The dorsales pollicis.

(*d*) The dorsalis indicis.

Arteries of the Fingers and Thumb.—The palmar surfaces of the *three inner fingers* are supplied by digital branches of the superficial palmar arch, while the dorsal surfaces of the same fingers are supplied over the first phalanges by branches of the dorsal metacarpals, the remaining phalanges being nourished by twigs from the digital arteries. The *index finger* has two arteries, radialis indicis and dorsalis indicis in addition to a digital branch from the superficial palmar arch; and the *thumb* has two dorsal arteries—dorsales pollicis and two

palmar; the latter being derived from the princeps pollicis. It may be roughly stated that, in amputation of the three inner fingers beyond the first phalanges, only two arteries are divided; while in the index finger three, and in the thumb four vessels require ligature.

Palmar Fascia.—The palmar fascia consists of three portions—a central and two lateral. The lateral parts cover the muscles of the thenar and hypothenar eminences, while the central portion forms a roof for the flexor tendons. The latter section is triangular in shape, and its apex, to which the palmaris longus is attached, is directed towards the wrist; the base divides into four processes which are attached to the sheaths of the flexor tendons over the first phalanges, and to the periosteum of the phalanges; in addition, small slips dip downwards between the fingers to blend with the transverse metacarpal ligament.

In Dupuytren's contraction, one or more of the fingers (most commonly the ring and little fingers), are bent partly or completely towards the palm of the hand, the flexion being brought about by the contraction of the palmar fascia, and its digital prolongations. The skin is normally loosely connected to the palmar fascia by fibrous bands; they also become shortened in this deformity, so that the skin becomes intimately adherent to the fascia.

Nerve Supply of Digits.—A knowledge of the nerve distribution to the digits is essential for the correct diagnosis of a nerve lesion.

When the ulnar nerve is divided *above* the origin of its dorsal cutaneous branch, epicritic sensibility is lost over the little finger, the ulnar half of the ring finger, and the corresponding portions of the palmar and dorsal surfaces of the hand. Protopathic sensibility is wanting over the little finger and the lower half of the hypothenar

eminence. If the ulnar is severed *below* its dorsal branch, the resulting sensory disturbance is much less prominent.

If the median nerve is divided above the wrist, epicritic sensibility cannot be detected over the lower half of the thenar eminence, the corresponding portion of the palm, and both surfaces of the outer three and a half digits. Protopathic sensibility is absent from the palmar and dorsal aspects of the terminal phalanx of the thumb, over the front of the index and middle fingers, the radial side of the ring finger, and over the dorsal surfaces of the index and middle fingers.

Sheaths of the Flexor Tendons.—The flexor tendon sheaths form fibrous tunnels, which extend from the heads of the metacarpal bones to the bases of the terminal phalanges. The sheath is attached to the margins of the anterior surfaces of the first and second phalanges, being very thick opposite the bones but thin opposite the joints. Each sheath is lined by synovial membrane, which, in the case of the thumb and sometimes the little finger, extends upwards beneath the anterior annular ligament. This fact explains the tendency shown by suppuration within the sheath to pass upwards to the front of the wrist in the case of the thumb and little finger, while it rarely extends to the palm from the remaining fingers.

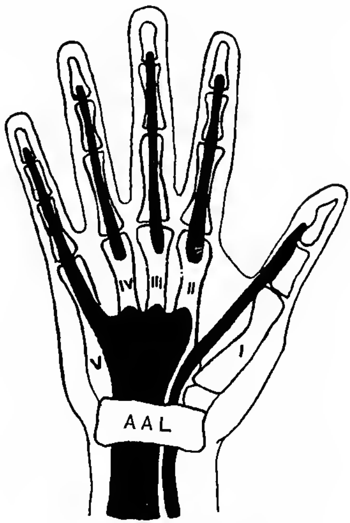
The synovial membrane clothes the inner surface of the sheath, and is reflected on to the tendons by means of delicate bands, the vincula; these bands convey nutrient arteries to the tendons.

Any digit may be the site of a suppurative inflammation or *whitlow*. This is either superficial, or may affect the tendon sheath or the bone, and it is important to remember that the pulp of the finger lies directly on the periosteum of the terminal phalanx. Accordingly,

a whitlow in the pulp of the finger readily extends to the periosteum, causing necrosis of part of that phalanx.

Anterior Annular Ligament and Synovial Sheaths.—The anterior annular ligament binds down the flexor

Fig. 8.—Anterior Annular Ligament and Synovial Sheaths.



1, 11, 111, 1V, V, Metacarpal bones.
AAL, Anterior Annular Ligament.

tendons to the front of the carpus. It is attached to the tubercle of the navicular and the ridge of the trapezium (os multangulum majus) externally, and to the hook of the unciform (os hamatum) and the pisiform bone internally. The chief structures passing over the ligament are—the ulnar nerve and vessels, and the tendon of the palmaris longus.

The area intervening between the anterior annular ligament and the carpus is frequently termed the carpal tunnel. It is occupied by the median nerve, the tendons of the superficial and deep flexor digital muscles, and

the tendon of the flexor longus pollicis. The tendons of the flexor sublimis and profundus digitorum are enveloped in a common synovial sheath extending one and a half inches above the annular ligament. Reaching the palm the sheath expands, forming the great palmar bursa, and then divides into four diverticula. The innermost passes to the base of the terminal phalanx of the little finger, the remaining three only reaching the middle of the metacarpal bones.

The tendon of the flexor longus pollicis has a separate sheath which begins one and a half inches above the ligament, and is continuous with the digital sheath of the thumb. (Fig. 8).

When the common synovial sheath is distended with fluid it bulges into the palm and in front of the wrist. The central part is constricted by the annular ligament; the swelling accordingly presents an hour-glass appearance. Such accumulations of fluid are best evacuated by an incision to the inner side of the tendon of the palmaris longus, injury to the median nerve and ulnar vessels being thus avoided.

The Dorsum of the Wrist.—Towards the inner side, the head of the ulna forms a rounded prominence, and its styloid process may be felt a little below and internal to it. On the back of the radius a small tubercle can be distinguished which separates the tendon of the extensor longus pollicis from the tendon of the extensor carpi radialis brevis.

The styloid process of the radius is readily detected between the extensor longus pollicis and the remaining extensor tendons of the thumb. Notice that it lies about half an inch nearer the hand than the corresponding process of the ulna. This is an important diagnostic factor in distinguishing between a Colles' fracture and a backward dislocation of the wrist.

Table of Insertions of the Important Tendons of the Wrist and the Digits.

Tendon.	Insertion.
Flexor carpi ulnaris	Pisiform bone.
Extensor carpi ulnaris	Dorsal surface of base of 5th metacarpal.
Flexor carpi radialis	Palmar surface of bases of 2nd and 3rd metacarpals.
Extensor carpi radialis longus	Dorsal surface of base of 2nd metacarpal.
Extensor carpi radialis brevis	Dorsal surface of base of 3rd metacarpal.
Flexor longus pollicis	Palmar surface of base of distal phalanx of thumb.
Extensor longus pollicis	Dorsal surface of base of distal phalanx of thumb.
Flexor brevis pollicis	Margins of base of proximal phalanx of thumb.
Extensor brevis pollicis	Dorsal surface of base of proximal phalanx of thumb.
Extensor ossis metacarpi pollicis (abductor pollicis longus)	Dorsal surface of base of 1st metacarpal.
Flexor sublimis digitorum	Margins of 2nd phalanges of fingers.
Flexor profundus digitorum	Palmar surface of base of distal phalanges of fingers.
Extensor communis digitorum	Dorsal surface of bases of 2nd and distal phalanges of fingers.

Dorsum of the Hand and Fingers.—The bases of the second and third metacarpal bones can be felt on the back of the hand; that of the second metacarpal bone and the tubercle on the back of the radius, previously referred to, form important landmarks in excision of the wrist.

On the dorsum of the carpus the extensor tendons lie

superficially, and can be traced to the fingers and thumb. The tendon, which passes to the ring finger, is connected by fibrous slips to the tendons of the middle and little fingers.

It is well to notice the position and direction of the tendon of the extensor longus pollicis, which can be traced from the inner side of the tubercle on the back of the radius to the distal phalanx of the thumb. It crosses the radial artery as that vessel enters the first interosseous space.

The remaining tendons at the back of the wrist are indistinct.

As the extensor tendons pass over the radius and ulna, they are bound to these bones by the posterior annular ligament, which is but a thickened portion of the deep fascia of the forearm.

Beneath this ligament the extensor tendons pass enclosed in six synovial compartments—

1st Compartment	Abductor pollicis longus. Extensor brevis pollicis.
2nd Compartment	Extensor carpi radialis longus. Extensor carpi radialis brevis.
3rd Compartment	Extensor longus pollicis.
4th Compartment	Extensor communis digitorum. Extensor indicis propius.
5th Compartment	Extensor minimi digiti (extensor quinti digiti proprius).
6th Compartment	Extensor carpi ulnaris.

These sheaths are prolonged downwards for a variable distance on to the back of the hand ; in this situation they are not protected by the annular ligament, and hence hernial protrusions of the synovial membrane may occur.

Inferior Radio-ulnar Joint.—Two ligaments are found in connection with this joint—(*a*) capsular, and (*b*) an articular disc. The capsule is very lax and stretches from the inferior margins of the radius and ulna to the articular disc. Extending upwards for a short distance between the bones of the forearm, is a portion of the capsule termed the recessus sacciformis.

The movements of pronation and supination occur at the radio-ulnar joints. The muscles which cause supination are the biceps, the brachio-radialis and the supinator brevis. There are three pronator muscles, namely—the pronator teres, the pronator quadratus, and the flexor carpi radialis.

Wrist-Joint (*Radio-carpal*).—The wrist-joint is formed above by the lower surface of the radius and the articular disc ; below it is bounded by the navicular, semilunar (os lunatum), cuneiform (os triquetrum), and their interosseous ligaments. Four ligaments are present—anterior, posterior, radial collateral, and ulnar collateral. The anterior and posterior ligaments spring from the inferior margins of the bones of the forearm and articular disc ; the anterior band is attached below to the first row of carpal bones, and to the os magnum (os capitatum), while the posterior is fixed to the navicular, lunate, and triquetral (cuneiform) bones. The radial collateral connects the radial styloid to the navicular ; the ulnar collateral passes from the ulnar styloid to the os triquetrum.

Four movements are permitted at the wrist-joint, namely,—flexion, extension, abduction (radial flexion), and adduction (ulnar flexion). The intercarpal joints greatly aid flexion, abduction, and adduction. Owing to the radial styloid reaching a lower level than the ulnar styloid, adduction is more extensive than abduction.

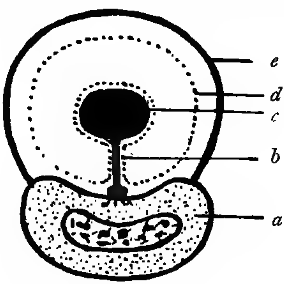
Arterial Supply.—Branches from the anterior and posterior carpal arches.

Nerve Supply.—The ulnar, median, and posterior interosseous nerves.

Table of the chief Muscles acting upon the Wrist-Joint.

Flexors.	Extensors.
Flexor carpi radialis. Palmaris longus. Flexor carpi ulnaris.	Extensor carpi radialis longus. Extensor carpi radialis brevis. Extensor carpi ulnaris.
Abductors.	**Adductors.**
Flexor carpi radialis. Extensor carpi radialis longus. Abductor longus pollicis. Extensor brevis pollicis.	Flexor carpi ulnaris. Extensor carpi ulnaris.

Fig. 9.—Transverse Section of a Digital Sheath.



a, Phalanx.
b, Vinculum conveying Artery to Tendon.
c, Tendon of Flexor Profundus Digitorum.
d, Synovial Membrane.
e, Fibrous Wall of Sheath.

Synovial Membranes of Carpus.—Six synovial membranes are normally present in the carpus :—

1. Pisiform + cuneiform (os triquetrum).

2. Trapezium (os multangulum majus) + thumb metacarpal.
3. Trapezium and trapezoid (os multangulum minus) + navicular.
4. Trapezoid, os magnum (os capitatum), and unciform (os hamatum) + four inner metacarpals.
5. Radius and articular disc + navicular, semilunar (os lunatum), and cuneiform.
6. Navicular, semilunar, and cuneiform + os magnum and unciform.

Joints of Digits.—The metacarpo-phalangeal and the interphalangeal articulations are united by strong palmar and lateral ligaments, the extensor tendons supporting the bones behind. Owing to the palmar ligaments of the metacarpo-phalangeal joints being firmly fixed to the phalanges and only loosely to the metacarpal bones, these bands are torn from their upper attachments in backward dislocations, and frequently form obstacles to the reduction of the dislocation.

Short Muscles of the Hand.—The hypothenar eminence comprises the abductor, opponens, and flexor brevis minimi digiti. They are all supplied by the ulnar nerve. The abductor and flexor brevis are inserted into the ulnar side of the base of the proximal phalanx of the little finger, while the opponens is attached to the ulnar aspect of the palmar surface of the fifth metacarpal.

Three muscles form the thenar eminence, namely—the abductor, opponens, and superficial head of the flexor brevis pollicis. The abductor and the superficial head of the flexor brevis are fixed to the radial side of the base of the proximal phalanx of the thumb (the adductors and the short head of the flexor brevis, which lie on a deeper plane, are inserted into the ulnar side of the base of the same bone). The opponens pollicis is

attached to the radial margin of the first metacarpal. Two nerves supply the short muscles of the thumb, the median the superficial ones, and the ulnar the deep ones.

The lumbricales are four in number, and arise from the tendon of the flexor profundus digitorum. Each lumbrical winds round the radial side of its finger to be inserted into the radial side of the dorsal expansion. They flex the metacarpo-phalangeal and extend the interphalangeal joints.

Seven interossei muscles are present, four dorsal and three palmar. The dorsal group abduct, and the palmar group adduct the fingers, from and to the middle line of the middle digit. In addition, the interossei aid the lumbricales. The interossei are inserted into the lateral margins of the dorsal expansion, and also into the base of the proximal phalanx of each finger. All the interossei and the two inner lumbricales are supplied by the ulnar nerve, while the two outer lumbricales are innervated by the median.

SECTION II

THE INFERIOR EXTREMITY

SURFACE ANATOMY OF THE GLUTÆAL REGION AND THIGH

THE iliac crest, with its anterior and posterior spines, should be first distinguished. In muscular individuals the crest forms the floor of a sulcus, the iliac furrow. The posterior superior iliac spine is a very useful landmark, as it is immediately behind the centre of the sacro-iliac joint. On the outer side of the thigh the great trochanter can be identified; its apex lies one hand's-breadth below the crest of the ilium. The ischial tuberosity forms a prominent landmark on flexion of the hip; in extension, its outline is somewhat obscured by the glutæus maximus.

The great sciatic nerve passes down between the great trochanter and the tuber ischii, slightly nearer to the latter than to the former.

During extension of the hip, the glutæal fold runs transversely across the lower part of the buttock. Remember that this furrow is a superficial crease, and is not produced by, nor does it correspond with, the lower border of the glutæus maximus. When the hip-joint is flexed, as in tubercular disease, there is a loss or diminution of the sulcus, but in congenital dislocation of the hip the fold is shorter and deeper than normal.

In male subjects the spine of the pubes is easily

recognised. The area between the pubic spine and the anterior superior iliac spine is bridged by the inguinal (Poupart's) ligament, the concavity of the ligament being directed upwards.

A line projected vertically downwards from the middle of Poupart's ligament passes over the centre of the hip-joint. In spare individuals the head of the femur can be palpated if the limb be extended and rotated outwards.

Several methods have been devised for the purpose of demonstrating the displacement of the great trochanter in deformities and injuries of the hip.

(*a*) *Nélaton's Line.*—This is drawn from the anterior superior iliac spine to the most prominent part of the tuber ischii; it normally touches the apex of the great trochanter, and traverses the centre of the hip-joint.

(*b*) *Chiene's Lines.*—Two strips of metal or pieces of tape are used: the upper is laid over the anterior superior iliac spines, and the lower over the highest point of the great trochanters. In a healthy person these lines will be parallel; if one trochanter be displaced upwards, the lower line will incline towards the upper on the injured side.

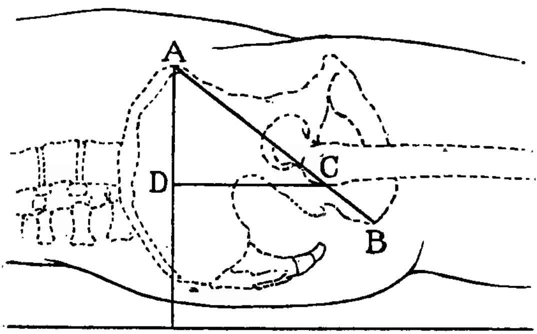
(*c*) *Bryant's Triangle.*—With the patient in the supine position the following lines are drawn:—(i) vertically from the anterior superior iliac spine; (ii) from the same spine to the summit of the great trochanter; and (iii) from the apex of the trochanter at right angles to the first line. (Fig. 10).

Three branches of the internal iliac artery appear in the buttock through the great sacro-sciatic foramen, the glutæal entering along the upper border of the piriformis, and the inferior glutæal (sciatic) and pudendal (pudic) along the lower border of that muscle. The junction of the upper and middle thirds of a line drawn

from the posterior superior iliac spine to the apex of the great trochanter indicates the site of the glutæal, while the junction of the lower and middle thirds of a line drawn from the posterior superior iliac spine to the tuber ischii marks the emergence of the inferior glutæal and the pudendal.

At the back of the thigh the prominence formed by the hamstring muscles may be felt. These arise in one group from the tuber ischii, but separate below to enclose the popliteal space. The biceps can be traced to the head of the fibula; the semimembranosus and

Fig. 10.—Bryant's Triangle and Nélaton's Line.



A B. Nélaton's Line. A C D. Bryant's Triangle.

semitendinosus pass to the inner condyle and shaft of the tibia respectively.

On the front of the thigh the quadriceps extensor forms a fleshy mass, having the rectus femoris in the middle, and the vasti laterally. The swelling formed by the vastus internus is well marked, and extends almost as far as the knee.

Abduct the hip and examine the adductors. When traced upwards, the tendon of the adductor longus can be followed to the body of the pubes; below, the tendon

of the adductor magnus descends to the adductor tubercle on the femur. In front of this latter tendon the anastomotica branch of the femoral artery runs downwards; and just above the adductor tubercle the superior internal articular artery winds round the femur. These points should be remembered when performing osteotomy of the femur by Macewen's method.

The ilio-tibial band will be seen on the outer aspect of the thigh. It extends from the iliac crest to the external condyle of the tibia, and into this band the glutæus maximus and tensor fasciæ femoris are inserted.

Lymphatic Glands of the Groin.—A great many lymphatic glands are situated in front of Scarpa's triangle, and it is customary for anatomists to divide the glands, conventionally, into four quadrants. Owing to the free anastomosis occuring between the members of the various groups, such a division is of very little use to the surgeon, and so from the standpoint of the latter we may recognise three groups. (*a*) The *inguinal* nodes; these are arranged more or less obliquely and lie immediately below and parallel with Poupart's ligament. Into them drain the superficial lymphatics of the anterior abdominal wall below the umbilicus, the glutæal region, the scrotum, the superficial lymphatics of the penis, the external genitals of the female, including the lower third of the vagina and the urethra, the perineum, and the lower part of the anal canal. Their efferents pierce the cribriform fascia, go through the femoral canal, and terminate in the lower iliac glands. (*b*) The *superficial subinguinal* nodes are placed almost vertically along the line of the femoral artery, and mainly drain the superficial structures of the lower extremity. In the majority of cases, their efferent ducts have the same course and destination as the inguinal group. (*c*) The *deep subinguinal* nodes are situated beneath the fascia

lata and accompany the femoral vein. They receive the deep lymphatics of the lower extremity and the deep lymphatics of the penis, and terminate in a similar manner to the inguinal glands.

The superficial lymphatic vessels of the lower extremity form two groups—antero-internal and postero-external. They are associated with the internal and external saphena veins. The deep lymphatics accompany the main arteries.

Superficial Fascia.—In the groin this fascia consists of two strata. The *superficial layer* is fatty, and frequently the site of lipomata. The *deep layer* is membranous and is firmly attached to the fascia lata just below Poupart's ligament; it thus hinders the passage of superficial collections of urine from the front of the abdomen down the thigh.

Fascia Lata.—The fascia lata springs from the pubes, Poupart's ligament, and the iliac crest. Externally, it is much thickened and forms the ilio-tibial band. Below, the fascia is attached to the bony prominences and tendons in the vicinity of the knee-joint, and becomes continuous with the popliteal fascia. Three intermuscular septa are given off from its deep surface; they are fixed to the linea aspera. The internal septum intervenes between the extensors and the adductors; the external separates the extensors from the flexors, while the posterior septum is very delicate and passes between the adductors and the flexors. The thigh accordingly is divided into three compartments—anterior, posterior, and internal; the

Anterior contains the extensor muscles and the anterior crural nerve; the

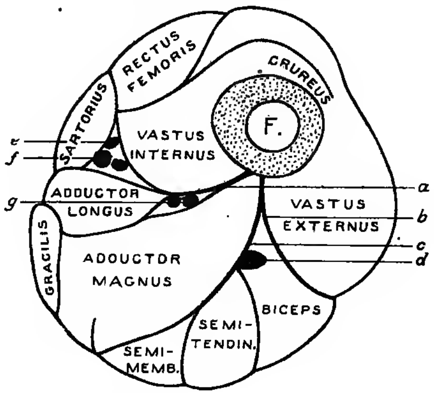
Internal contains the adductor muscles and the obturator nerve; the

Posterior contains the flexor muscles and the great sciatic nerve. (Fig. 11.)

The fascia lata is interrupted at the saphenous opening.

Saphenous Opening.—This is a crescentic-shaped depression in the fascia lata just below the inner extremity of Poupart's ligament; the dimensions are one and a half inches long and half an inch wide.

Fig. 11.—Transverse Section through Middle of Left Thigh.



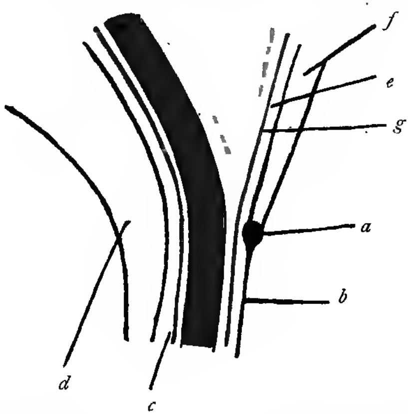
a, Internal Intermuscular Septum.
b, External Intermuscular Septum.
c, Posterior Intermuscular Septum.
d, Great Sciatic Nerve.
e, Internal Saphenous Nerve.
f, Femoral Vessels.
g, Profunda Vessels.

The outer margin, or falciform process, is strong, being formed by the iliac portion of the fascia lata. On the contrary, the inner margin is weak, and is constituted by the pubic element of the fascia. The superior cornu is prolonged as Hey's ligament in front of the upper part of the femoral sheath to be attached to Gimbernat's ligament; the inferior cornu passes beneath the internal saphenous vein to blend with the posterior wall of the sheath.

The opening is roofed over by the *cribriform fascia*, a thin layer of fascia lata which is pierced by the lymphatics and the internal saphenous vein; it forms one of the coverings of a femoral hernia.

Scarpa's Triangle. (Femoral trigone).—Externally, the triangle is bounded by the inner edge of the sartorius; internally, by the corresponding border of the adductor longus; Poupart's ligament serves as the base. The floor is a muscular one, and from without

Fig. 12.—Diagram showing Formation of Femoral Sheath.



a, Poupart's Ligament.
b, Fascia Lata.
c, Fascia Iliaca.
d, Ilio-psoas.
e, Fascia Transversalis.
f, Anterior Abdominal Wall.
g, (Yellow) Parietal Peritoneum

inwards is formed by the ilio-psoas, pectineus, a small portion of the adductor brevis, and the adductor longus. Within this triangle are found the femoral vessels enclosed in their sheath, the anterior crural and the femoral branch of the genito-femoral nerves, the deep subinguinal lymph glands (*see* ante), and the femoral canal.

Femoral Sheath.—This sheath encloses the femoral

vessels and canal in Scarpa's triangle, and is formed by the prolongations of certain fasciæ of the abdomen on the vessels—its anterior layer being a continuation of the fascia transversalis, which lines the anterior abdominal wall, while its posterior layer is derived from the fascia iliaca, covering the psoas and iliacus (Fig. 12). The sheath is funnel-shaped, measures two inches in length, and is divided by thin septa into three compartments. The outer compartment contains the femoral artery and the femoral branch of the genito-femoral nerve; the middle lodges the femoral vein, while the internal division is occupied by lymphatics, and is termed the femoral or crural canal.

Femoral Canal.—It is half an inch long, and extends from Poupart's ligament to the saphenous opening. The orifice of the canal is known as the femoral ring. Into the ring a small portion of extra-peritoneal fat, the septum crurale, projects. The femoral canal has the following boundaries:—in *front*, Poupart's ligament; *behind*, the pectineus, with the fascia covering it (the pubic portion of the fascia lata), and the os pubes; *internally*, the base of Gimbernat's ligament; *externally*, the femoral vein and the inner septum of the sheath.

Gimbernat's Ligament.—This is a prolongation of Poupart's ligament on to the inner inch of the ilio-pectineal line. It is triangular in shape, the apex being attached to the spine of the pubes while the base is free, concave, and sharp, forming the inner boundary of the femoral canal.

Femoral Hernia.—The upper surface of Gimbernat's ligament proves an efficient barrier to the passage of any of the abdominal contents into the thigh internal to the femoral vessels, while external to the vessels, the fusion of the fascia transversalis and the fascia iliaca with Poupart's ligament likewise prevents hernia.

Accordingly, femoral hernia protrudes through the femoral ring and femoral canal, and reaches the surface by passing through the saphenous opening. At this spot the hernia abuts against the falciform edge, which frequently causes the swelling to alter its direction, and to mount up over Poupart's ligament, where it may simulate an inguinal hernia. However, the relation of the neck of the sac to Poupart's ligament is sufficient to differentiate between the two forms, the neck being above the ligament in the inguinal, but below it in the femoral form of hernia. The relation of the neck of the sac to the spine of the pubes is a valuable diagnostic point. The spine is to the outer side of an inguinal, but on the inner side of a femoral, hernia.

The sac of a femoral hernia, as it passes through the femoral ring, has important relations: (*a*) the deep epigastric vessels lie above and to its outer side; (*b*) the femoral vein is separated merely by a septum of the sheath; and (*c*) the spermatic cord in the male, and the round ligament in the female, are almost immediately over the sac. The obturator artery, which is normally a branch of the internal iliac artery, does not come into relation with the neck of the sac; but when, as occasionally happens, it arises from the deep epigastric, it may be wounded in dividing the constriction around a strangulated femoral hernia.

The coverings of a femoral hernia are—

Peritoneum (sac).
Extra-peritoneal fat.
Septum crurale.
Anterior wall of femoral sheath.
Cribriform fascia.
Superficial fascia.
Integument.

Abnormal Obturator Artery.—The course of this

artery is of great surgical importance. In the majority of cases the artery is the enlarged pubic branch of the deep epigastric. The common arrangement is for the aberrant vessel to reach the obturator foramen by crossing over the external iliac vein, thus passing to the *outer* side of the femoral ring; this is termed the "non-dangerous" variety. Occasionally, however, the obturator arches over the ring, and descends on the abdominal surface of Gimbernat's ligament to enter the obturator canal—the "dangerous" form. In strangulated femoral hernia the constricting agent is usually formed by the sharp edge of Gimbernat's ligament; this has to be divided by incising inwards, and accordingly the artery may be severed.

Femoral Artery.—The femoral artery stretches from Poupart's ligament to the opening in the adductor magnus, and its course may be indicated by a line drawn from a point midway between the anterior superior spine and the pubic symphysis, to the adductor tubercle of the femur, the thigh having been previously flexed, abducted, and rotated outwards.

After a course of about one and a half to two inches, the common femoral is usually stated to divide into superficial and deep.

Femoral Artery in Scarpa's Triangle.—In Scarpa's triangle the artery is superficial.

Relations.—

Front

Skin and fasciæ.
Superficial veins and lymphatic glands.
Internal cutaneous and femoral branch of genito-femoral nerves.
Sartorius muscle.

Externally		*Internally*
Anterior crural nerve.	**A**	Femoral vein.
	Behind	

Psoas, pectineus, and nerve to pectineus.
Adductor longus.
Profunda artery and vein.
Femoral vein (at apex of triangle).
Capsule of hip-joint.

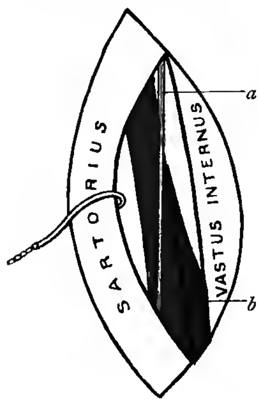
Anterior Crural Nerve.—Arising from the lumbar plexus (L. 2. 3. 4.), the anterior crural enters the thigh by passing beneath Poupart's ligament, external to the femoral sheath. It is deeply placed between the iliacus and the psoas muscles, and after a short course splits into anterior and posterior divisions, the two being separated by the external circumflex vessels. In addition to articular twigs to the hip and knee, the nerve supplies the iliacus, sartorius, pectineus, and the quadriceps extensor. Three sensory branches spring from the anterior crural, namely, the middle cutaneous, internal cutaneous, and the internal saphenous. The internal saphenous pierces the roof of Hunter's canal in its lower part, and appears in the interval between the sartorius and the gracilis. It then accompanies the internal saphenous vein down the leg, and can be traced as far as the middle of the inner aspect of the foot. Both the middle and the internal cutaneous nerves perforate the fascia lata at two places, and supply the integument of the corresponding portions of the thigh down to the knee. The external area of the thigh is innervated by the *external cutaneous*, a branch of the second and third lumbar nerves. It leaves the abdomen under cover of Poupart's ligament, immediately to the inner side of the anterior superior iliac spine, and becomes cutaneous at two separate points, the posterior division emerging about two inches below the spine, and the

anterior division a similar distance distal to the posterior.

Femoral Artery in Hunter's Canal.—Hunter's canal, or the adductor canal, is an intermuscular space extending from the apex of Scarpa's triangle to the opening in the adductor magnus.

The canal is bounded externally by the vastus internus; internally and posteriorly by the adductor longus and magnus; and is roofed over by a layer of

Fig. 13.—Diagram showing Relations of Femoral Artery in Hunter's Canal.



a, Internal Saphenous Nerve. *b*, Femoral Vein.

fascia, which extends from the adductors to the vastus internus, and on which the sartorius rests (Fig. 13).

Within the canal are the femoral vessels and two nerves, the internal saphenous nerve and the nerve to the vastus internus. The femoral vein is first external then posterior to the artery, passing to the inner side on reaching the apex of Scarpa's triangle. One named branch is given off from the femoral artery in this region, the anastomotica magna. In performing osteotomy

of the lower part of the femur, it is important to remember that the main division of the anastomotica runs down upon the tendon of the adductor magnus.

Relations.—

Externally		Internally
	Front	
	Skin and fasciæ.	
	Sartorius.	
	Aponeurotic roof.	
	Internal saphenous nerve.	
Vastus internus.		Sartorius.
Nerve to vastus internus.	**A**	Adductor longus.
Femoral vein.		Adductor magnus.
	Behind	
	Femoral vein.	
	Adductor longus.	
	Adductor magnus.	

Branches of the Femoral Artery.—Previous to its division into superficial and deep, the common femoral sends off four small branches, two of which, the external pudics, pass inwards to supply the scrotum. The superficial epigastric artery crosses Poupart's ligament about its middle to ramify upon the lower part of the anterior abdominal wall, while the superficial circumflex iliac extends outwards to the iliac crest.

The *profunda artery* is given off from the outer side of the femoral artery; it then winds inwards beneath that vessel, and is separated from it by the adductor longus. By means of its circumflex and perforating branches, it forms a long anastomosing chain which extends from the glutæal region to the popliteal space. This anastomosis connects the internal iliac with the popliteal artery. The profunda vein lies superficial to the profunda artery.

The ascending branch of the external circumflex is

divided in excision of the hip-joint by the anterior method; the descending branch of the same artery accompanies the nerve to the vastus externus and can be traced in this muscle as far as the patellar anastomosis.

The upper part of the femoral artery may be the seat of aneurysm. Several causes have been mentioned as predisposing to aneurysm of this vessel: (*a*) its superficial position and consequent exposure to injury; (*b*) the proximity to the hip-joint, with its frequent movements; (*c*) the local increase of vascular tension where the large profunda branch arises.

Table of Branches of the Femoral Artery.

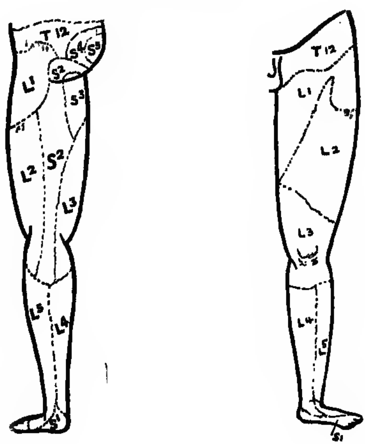
Femoral	Common	Superficial circumflex iliac.	
		Superficial epigastric.	
		Superficial external pudic.	
		Deep external pudic.	
	Superficial	Muscular.	
		Anastomotica magna.	
	Profunda	Internal circumflex	Ascending.
			Transverse.
			Articular to hip.
		External circumflex	Ascending.
			Transverse.
			Descending.
		Perforating.	

Ligature of the Femoral Artery.—Although the femoral artery lies quite superficially just below Poupart's ligament, it is hardly ever tied in this situation, owing to the number of small branches given off from the artery. The vessel is ligated either at the apex of Scarpa's triangle or in Hunter's canal. In the former position the *inner* edge of the sartorius forms the guide, the

muscle being displaced *outwards*; when tied in Hunter's canal, the *outer* border of the sartorius must be recognised and the muscle pulled *inwards*. It is in this region that the vessel can be most conveniently reached for performing arterio-venous anastomosis in cases of senile and pre-senile gangrene.

Obturator Nerve.—This branch of the lumbar plexus (L. 2, 3, and 4), crosses the pelvis lying along

Fig. 14.—CUTANEOUS AREAS OF THE LOWER EXTREMITY. (After HEAD.)



the inner border of the psoas, and passes over the obturator vessels to enter the thigh through the upper part of the obturator foramen. At this spot the nerve may be compressed by an obturator hernia. In the foramen the nerve divides into two, the anterior branch extending between the pectineus and adductor brevis, and giving off a twig to the hip-joint; the posterior branch is found between the adductor brevis and

adductor magnus, and terminates by piercing the ligament of Winslow to supply the knee.

Great Sciatic Nerve.—The great sciatic nerve is a thick bundle of nerve fibres, which essentially consists of four separate elements. These are from within outwards, the nerve to the hamstrings, the internal popliteal (tibial), the external popliteal (common peroneal), and the nerve to the short head of the biceps. The bundle emerges from the pelvis through the great sacro-sciatic foramen, below and behind the piriformis, and proceeds downwards, resting successively upon the os innominatum, superior gemellus, obturator internus, inferior gemellus, quadratus femoris, and adductor magnus. At a point a little below the middle of the thigh, the main trunk separates into its terminal divisions, the internal and external popliteal nerves. Overlapping the great sciatic are the piriformis and the glutæus maximus, while in the thigh it is crossed by the long head of the biceps. The nerve is accompanied by a branch of the inferior glutæal artery, called the comes nervi ischiadici.

The sciatic nerve may be reached by an oblique *incision* commencing at the lower border of the glutæus maximus. After dividing the superficial structures, the long head of the biceps is displaced inwards, and the nerve hooked up with the finger. The nerve has also been stretched by *forcibly flexing the hip* with the knee in the extended position, and it should be remembered that if the knee be flexed and the hip extended, the sciatic nerve is flaccid, while in the reverse position, as mentioned above, the nerve is tightly stretched.

Table of the Chief Nerves of the Thigh.

Nerve.	Origin.	Motor.	Articular.
Obturator .	L. 2. 3. 4 .	Adductors longus, brevis, and magnus; gracilis and obturator externus.	Hip and knee.
Anterior crural	L. 2. 3. 4 .	Vastus internus and externus, iliacus, crureus and subcrureus, sartorius, rectus femoris, and pectineus.	Hip and knee.
Great sciatic	Peroneal, L. 4. 5, S. 1. 2. Tibial, L. 4. 5, S. 1. 2. 3.	The sciatic supplies the biceps, semimembranosus, semitendinosus, and part of adductor magnus.	Hip (sometimes). Knee (through the peroneal and tibial branches).

The Buttock.—There are three bursæ in connection with the glutæus maximus, separating the muscle from the great trochanter of the femur, the tendon of the vastus externus, and the tuber ischii respectively. Enlargement of the ischial bursa constitutes the condition known as a "tailor's bottom." When the glutæus maximus is reflected, the glutæus medius, piriformis, superior gemellus, obturator internus, inferior gemellus, quadratus femoris, and the upper portion of the adductor magnus are displayed. The glutæus minimus lies under cover of the glutæus medius. Between the glutæus medius and the piriformis will be found the superior glutæal artery and nerve, the latter being the inferior in position. It is through this interval that the joint is opened in Kocher's arthrectomy of the hip. Observe

that the incision is passing between the internal rotators of the hip above, and the external rotators below.

Occupying the space between the piriformis and the superior gemellus are the inferior glutæal (sciatic) and pudendal (internal pudic) arteries; the great sciatic, small sciatic, and inferior glutæal nerves, also the small nerves to the obturator internus and quadratus femoris. The obturator externus tendon, accompanied by a branch of the internal circumflex artery, lies between the inferior gemellus and the quadratus femoris.

The superior and inferior glutæal arteries, and the pudendal, arise from the internal iliac. They emerge from the pelvis through the great sacro-sciatic foramen; the superior glutæal is above the piriformis, while the inferior glutæal and pudendal are below it. The pudendal winds over the spine of the ischium to enter the ischio-rectal fossa through the small sacro-sciatic foramen. As it lies upon the ischial spine, the nerve to the obturator internus is external, and the pudendal nerve internal to the artery.

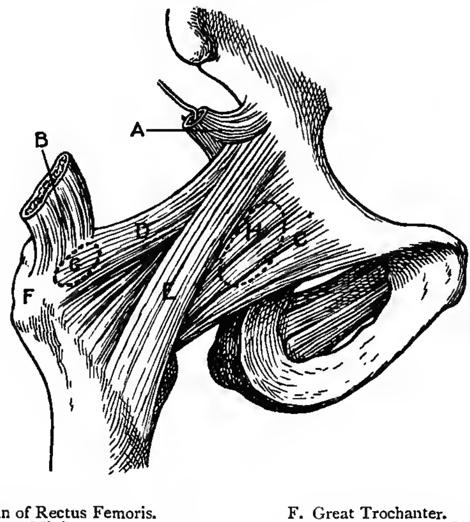
THE HIP JOINT.

This is an enarthrodial or ball-and-socket joint. Four proper ligaments are present—the capsular, ligamentum teres, labrum glenoidale (cotyloid), and transverse; these are reinforced by certain accessory bands, the ilio-femoral, pubo-capsular, ischio-capsular, and zonular.

The chief factors contributing towards the strength and security of the hip-joint, are: (*a*) the perfect coaptation of the femoral head and its deep socket, the acetabulum; (*b*) the strong capsular ligament and its accessory bands; (*c*) the length and oblique direction of the neck of the femur (Cunningham); (*d*) the powerful muscles in intimate connection with the capsule; and (*e*) the atmospheric pressure.

The capsular ligament closely invests the neck of the femur; in front, it is firmly attached to the anterior intertrochanteric line, while behind, the ligament is feebly fixed about half an inch above the posterior intertrochanteric line. Prolongations of the capsule, covered by synovial membrane, are reflected upwards

Fig. 15.—THE RIGHT HIP-JOINT (Anterior Aspect). (After TESTUT.)



A. Origin of Rectus Femoris.
B. Glutæus Minimus.
C. Capsular Ligament.
D. E. The Limbs of the Ilio-femoral Ligament.
F. Great Trochanter.
G. Bursa beneath Glutæus Minimus.
H. Ilio-psoas Bursa.

upon the neck; these retinacula, or cervical ligaments of Stanley, convey branches of the internal circumflex artery. Probably, arterio-sclerosis of these minute vessels is the cause of the eccentric atrophy which occurs in the neck of the femur in the aged, and which predisposes to fracture in this situation.

"The integrity of these ligaments plays an important part in determining union in fractures of the neck of the femur, both by keeping the fragments in position, and by maintaining the blood-supply to the short fragment" (Thomson and Miles).

The capsular ligament is immensely strong except below and behind. Occasionally a weakening occurs in the anterior wall owing to the upper bursa of the ilio-psoas communicating with the joint; the aperture is placed between the inner limb of the ilio-femoral and the pubo-capsular ligaments.

The ligamentum teres, attached both to the acetabulum and the head of the femur, is a triangular band conveying a branch of the obturator artery, or in exceptional cases, of the internal circumflex, to the head of the femur. According to the experiments of Sir Henry Morris, the ligament is "tightest in flexion combined with adduction and rotation outwards."

Of the accessory ligaments, the ilio-femoral or Y-ligament is the chief. This band is a quarter of an inch in thickness, and is fixed above to the anterior inferior iliac spine, while below the limbs diverge to be attached to the extremities of the anterior intertrochanteric line. Were it not for this ligament, a considerable amount of muscular energy would be expended in preserving the erect posture, as in this position, the weight of the body tends to tilt the pelvis backwards.

Notice how the floor of the acetabulum is separated from the pelvic cavity merely by a thin layer of bone. This may be perforated by the extension of tubercular disease from the joint, and the pelvic cavity opened into by the burrowing pus.

Regarding the synovial membrane, the special points to remember, are: (*a*) the cotyloid ligament is covered

on both surfaces; and (*b*) the ligamentum teres is surrounded by the membrane, and therefore excluded from the joint cavity.

Dislocations of the hip-joint fall into two classes, forwards and backwards. The former occur when the limb is in the abducted position, the latter during adduction and internal rotation. The ligamentum teres, together with the lower and back part of the capsule, are torn, but the ilio-femoral ligament usually remains entire.

In congenital dislocation of the hip, the acetabulum is imperfectly developed, the head of the femur elongated, the capsular ligament thick but *intact*, the hamstrings and adductors shortened, and the short horizontal muscles behind the joint are lengthened.

Movements.—Flexion ceases when the thigh touches the anterior abdominal wall; it is produced by the ilio-psoas, pectineus, sartorius, and rectus femoris. *Extension* is checked by the ilio-femoral ligament; the extensors are the glutæi and the hamstrings. *Abduction* is restrained by the pubo-capsular ligament; the muscles producing this movement are the glutæi and the tensor fasciæ femoris. *Adduction* is limited by the upper portion of the ilio-femoral band; the adductors are the longus, brevis, and magnus; the pectineus, gracilis, lower part of glutæus maximus and obturator externus. *External rotation* is checked by the outer limb of the ilio-femoral ligament; it is performed by the obturators, gemelli, piriformis, quadratus femoris, and glutæus maximus. *Internal rotation* is prevented from becoming excessive by the ischio-capsular ligament; the chief internal rotators are the glutæus medius, glutæus minimus, and the tensor fasciæ femoris.

Circumduction is due to a combination of the above muscles.

Arterial Supply.—Internal circumflex, external circumflex, obturator, superior glutæal, and inferior glutæal arteries.

Nerve Supply.—Anterior crural, obturator, and either the great sciatic or the nerve to the quadratus femoris.

Table of the Chief Muscles acting upon the Hip.

Muscle.	Origin.	Insertion.	Nerve Supply.
Glutæus Maximus	Posterior $\frac{1}{6}$ of dorsum ilii; lumbar fascia; back of sacrum and coccyx; great sacro-sciatic ligament.	Glutæal ridge of femur and ilio-tibial band.	Inferior glutæal
Glutæus medius	Dorsum ilii between superior and middle curved lines; fascia lata.	Outer surface of great trochanter.	Superior glutæal.
Glutæus minimus	Dorsum ilii between middle and inferior curved lines.	Anterior surface of great trochanter.	Superior glutæal.
Pectineus	Ascending ramus of pubes.	Posterior aspect of femur just behind and below the lesser trochanter.	Anterior crural.
Ilio-psoas	*See* Abdomen.	Lesser trochanter and slightly below it.	Iliac portion by the anterior crural; psoas portion by the lumbar plexus.
Rectus femoris	Anterior inferior iliac spine; groove immediately above brim of acetabulum.	Quadriceps extensor into upper border of patella.	Anterior crural.
Piriformis	Anterior surface of sacrum and upper margin of great sacro-sciatic notch.	Upper border of great trochanter.	Sacral plexus.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Obturator Internus	Internal surface of obturator membrane and adjacent portion of bone.	Upper border of great trochanter.	Sacral plexus.
Obturator Externus	External surface of obturator membrane and adjacent portion of bone.	Digital fossa of femur.	Obturator.
Quadratus femoris	Outer surface of tuber ischii.	Quadrate line of femur.	Sacral plexus.
Adductor brevis	Descending ramus of pubes.	Inner lip of linea aspera of femur.	Obturator.
Adductor longus	Anterior surface of body of pubes.	Inner lip of linea aspera of femur.	Obturator.
Adductor magnus	Conjoined ischio-pubic rami and lower part of tuber ischii.	Inner lip of linea aspera; upper part of internal epicondylic line; adductor tubercle.	Obturator.

Fractures of the Femur.—Fracture of the *neck* may occur either—(*a*) at the junction of the head with the neck, or (*b*) through the base of the neck. The line of fracture in the former case is intracapsular; in the latter, it is intracapsular in front and extracapsular behind. Owing to the neck being driven into the shaft between the trochanters, fracture through the base is usually impacted.

If the cervical ligaments are torn, the lower extremity is everted by the weight of the limb, which naturally tends to roll outwards, and is shortened by the glutæi, hamstrings, and adductors.

Fracture of the great trochanter sometimes happens as a result of direct violence. The detached fragment is drawn upwards and backwards by the glutæi, piriformis, obturator internus, and gemelli.

In *oblique fractures of the shaft* of the femur (upper and middle thirds), the proximal fragment is tilted forwards by the ilio-psoas and glutæi muscles, while the lower portion is drawn upwards behind it by the hamstrings and adductors, and rotated out by the weight of the limb.

Fracture of the lower end of the femur i.e. supra-condylar, may cause such injury to the popliteal vessels as to lead to gangrene, or, by pressure on the popliteal nerves, to cause paralysis.

In this fracture the distal fragment is drawn backwards by the action of the gastrocnemius, plantaris, and popliteus; extension of the limb usually increases the displacement.

SURFACE ANATOMY OF THE KNEE.

Anteriorly the patella lies superficially. When the limb is extended the patella is very movable, but if the limb be flexed, the patella is fixed against the anterior surface of the femur.

From the patella the ligamentum patellæ may be traced to the tuberosity of the tibia. Over the patella is the prepatellar bursa, which is frequently enlarged, forming *housemaid's knee.* Beneath the ligamentum patellæ is the infrapatellar bursa; when this becomes distended it assumes an hour-glass shape, its middle being compressed by the ligament.

The condyles of the tibia should be examined, and on passing the finger backwards over the external condyle, the head of the fibula can be palpated. It occupies the same plane as the tuberosity of the tibia, but lies towards the posterior surface of the bone.

The internal condyle of the femur, with its small adductor tubercle, is distinct. A line drawn from this tubercle to the upper angle of the trochlear surface

indicates the junction of the lower femoral epiphysis with the diaphysis. Notice the interval between the inner condyle of the femur and the corresponding condyle of the tibia. This indicates the line of the knee-joint and the position of the semilunar menisci: it is readily distinguished on flexing the leg.

On the outer side, the external femoral condyle is subcutaneous, but not so well defined as the internal. The ilio-tibial band forms a marked prominence, extending down to the external condyle of the tibia. This band is frequently mistaken (in certain positions of the limb) for the tendon of the biceps, which passes to the head of the fibula. The external popliteal (common peroneal) nerve is sheltered by the biceps, and it may, in thin subjects, be felt in this position.

When performing tenotomy of the biceps, care should be taken lest the nerve be injured.

The skin of the popliteal space is impressed by a transverse crease which lies some distance above the level of the knee-joint.

POPLITEAL SPACE.

If the knee be flexed, the lateral boundaries of the space formed by the hamstrings and the two heads of the gastrocnemius can be easily recognised.

Boundaries.—

Roof, skin, superficial fascia, and popliteal fascia.

Floor, the trigone of the femur, the ligament of Winslow, and the fascia over the popliteus muscle.

Internally, the semimembranosus, semitendinosus, and the inner head of the gastrocnemius.

Externally, the biceps, the outer head of the gastrocnemius, and the plantaris.

Contents.—Popliteal vessels and nerves, lymphatics, the geniculate branch of the obturator nerve, the termination of the external saphenous vein, and some twigs of the small sciatic nerve.

The internal popliteal (*tibial*) *nerve* lies in the middle line of the space immediately beneath the deep fascia, and crosses the popliteal vessels from without inwards. On reaching the lower border of the popliteus muscle the name of the nerve was formerly changed into the posterior tibial. The superficial muscles of the calf (gastrocnemius, soleus, and plantaris), and also the popliteus, are supplied by the internal popliteal. In addition, the nerve gives off three articular twigs to the knee-joint.

The external popliteal (*common peroneal*) *nerve* passes outwards, lying between the biceps and the outer head of the gastrocnemius. It then winds round the leg just below the head of the fibula, pierces the peronæus longus, and divides into the musculo-cutaneous (superficial peroneal) and the anterior tibial (deep peroneal).

The popliteal lymphatic nodes form a small group which receive the ducts accompanying the deep vessels of the back of the leg: they also drain the knee-joint.

Popliteal Artery.—This vessel extends from the opening in the adductor magnus to the lower border of the popliteus. At this point the artery divides into the anterior and posterior tibials, the former reaching the front of the leg by passing between the two heads of the tibialis posterior (posticus) and then piercing, or going above, the interosseous membrane.

Superficial to the artery will be found the tibial nerve and the popliteal vein—these structures lying external to the artery above, but internal to it at its lowest part. The vein is in intimate contact with the artery, and closely united to it by strong fascia: it is therefore a difficult matter to separate the two vessels.

The artery lies upon the trigone of the femur, the posterior ligament of the knee-joint, and the fascia covering the popliteus muscle. It is important to remember these deep relations during excision of the knee-joint, lest the artery be wounded. The popliteal artery is the commonest seat of surgical aneurysm.

Ligature of Popliteal Artery.—The artery may be reached in its upper part by an incision along the lower four or five inches of the line of the femoral artery, or by an incision in the mid-line of the popliteal space. In the former case, the sartorius and semimembranosus are retracted backwards, and the tendon of the adductor magnus, with the anastomotica magna artery lying upon it, pulled forwards. The popliteal artery will now be found embedded in the fat of the popliteal space. Pass the needle from the accompanying vein and nerve.

KNEE-JOINT

So far as the bones are concerned the knee is one of the weakest joints in the body, for it has no articular socket like the hip or shoulder, and no surrounding processes as in the elbow or ankle. However, owing to the powerful ligaments present, it is rarely dislocated. Its security depends greatly on the cruciate (crucial) ligaments, these being alternately tense during flexion and extension; they also limit rotation and tend to prevent lateral displacements. Three articular surfaces enter into it, namely, the lower end of the femur, the upper surface of the tibia, and the patella. Notice that the long axis of the tibia is vertical, but the long axis of the femur is oblique (especially in females). This anatomical fact explains why dislocation of the patella most commonly occurs in an outward direction.

Ligaments.—The joint has an articular capsule in

which we can recognise the *ligamentum patellæ,* passing from the inferior patellar margin to the lower part of the tuberosity of the tibia. It is flanked by the *collateral patellar ligaments*, which are prolongations of the fascia lata and the vasti muscles. Behind, the *posterior ligament of Winslow* unites the popliteal surface of the femur to the posterior border of the head of the tibia. It is reinforced by an oblique slip (running upwards and outwards) derived from the semimembranosus tendon. Laterally, are two strong bands, the *fibular and tibial collateral ligaments* (external and internal lateral). The former stretches from the external epicondyle of the femur to the outer surface of the head of the fibula, and splits the biceps tendon into two, while the tibial collateral arises from the internal epicondyle of the femur and goes to the shaft of the tibia just below the inner condyle. The *intra-articular ligaments* comprise the semilunar menisci (cartilages), the cruciate ligaments, the coronary ligaments, and three bands of synovial membrane, the ligamentum mucosum (plica synovialis) and the ligamenta alaria (plica alares).

Semilunar Menisci.—The internal meniscus is crescentic, while the external is almost circular. They are triangular in section, with the base at the circumference of the joint, and are bound to the head of the tibia by the coronary ligaments. The term cornua is applied to the extremities of the menisci; they have very intimate relations to the tibial attachments of the cruciate ligaments. The anterior cruciate intervenes between the anterior cornua of the menisci, and the posterior cruciate occupies the gap between the internal meniscus and the posterior ligament of the joint; it receives a strong slip from the external meniscus. Uniting the anterior margins of the two cartilages is a band—the transverse ligament.

It is very important to remember that the internal meniscus has a firm attachment to the tibial collateral ligament, and therefore constant straining of this ligament tends to loosen the cartilage, and thus bring about internal derangement of the joint.

Cruciate Ligaments.—The *anterior cruciate* is fixed above to the posterior portion of the internal surface of the external condyle, and runs downwards, forwards, and inwards, to a depression immediately in front of the spine, on the upper surface of the tibia. The *posterior cruciate* extends from the anterior part of the external surface of the internal condyle to a slight hollow just behind the tibial spine. The ligament passes downwards, backwards, and outwards.

Mechanism.—The knee is a ginglymus joint: its movements are flexion and extension, with some rotation in the flexed position.

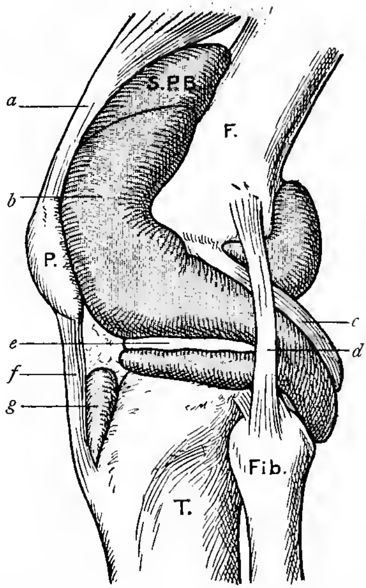
During extension the menisci move forwards; the anterior cruciate, the posterior ligament, and the collateral ligaments tighten; the posterior cruciate and the ligamentum patellæ relax; and lastly, towards the end of extension, the joint becomes firmly locked. Locking is caused by the internal condyle of the femur moving backwards upon the tibia, until the anterior part of the intercondylar notch comes into contact with the anterior cruciate ligament.

At the beginning of flexion the reverse process occurs. The internal femoral condyle moves forwards, thus unlocking the joint; the menisci pass backwards; the anterior cruciate, the posterior ligament, and the collateral ligaments slacken, while the posterior cruciate and the ligamentum patellæ tighten.

Synovial Membrane.—The synovial membrane forms a very large absorbtive surface, and hence the extreme gravity of the case when pyogenic organisms gain admission to the joint. The upper limit of the mem-

brane will be found about three fingers' breadth above the superior border of the patella, rising a little higher on the inner than the outer side. Traced downwards it lines the capsule, the deep aspect of the infra-patellar pad of fat, both surfaces of the menisci, and reaches the

Fig. 16.—The Synovial Membrane of the Knee.



a. Quadriceps.
b. Synovial Membrane.
c. Tendon of Popliteus.
d. Fibular Collateral Ligament.
e. Edge of Meniscus.
f. Ligamentum Patellæ.
g. Supra-patellar Bursa.
F. Femur.
P. Patella.
T. Tibia.
SPB. Supra-patellar bursa.

tibia along the coronary ligaments. The greater part of the cruciate ligaments is invested by the membrane, as is also the tendon of the popliteus. Stretching from the upper part of the intercondylar notch to the infrapatellar pad of fat, is a mass of adipose and elastic tissue, the

ligamentum mucosum; it is covered by synovial membrane. The lateral fringes of the infrapatellar pad of fat, with their synovial covering, are known as the ligamenta alaria. "It is possible that these ligaments act as a swab to distribute the synovia over the articular surfaces." (Davis).

When the synovial membrane is distended with fluid it bulges on each side of the patella where the capsule is thin, and lifts the patella off the femur—floating patella. Numerous bursæ are found in the vicinity of the knee, several of which frequently communicate with the joint cavity.

The chief bursæ are described in the following table—

Bursæ around the Knee.

Bursa	Situation	Communication with Joint
Suprapatellar .	Beneath quadriceps extensor .	Usually
Prepatellar . .	Generally between fascia lata and capsule of patella . .	*Nil*
Infrapatellar .	Under ligamentum patellæ .	Rarely
Semimembranosus	Between tendon and inner condyle of tibia	Often
Gastrocnemius (inner head)	Between tendon and inner condyle of femur	Often
Gastrocnemius (outer head)	Between tendon and outer condyle of femur	Sometimes
Bursa anserina .	Between sartorius, gracilis, semitendinosus, and tibial collateral ligament . . .	*Nil*
Biceps . . .	Between biceps and fibular collateral ligament . . .	*Nil*
Fibular collateral ligament . .	Between the ligament and the popliteus	*Nil*
Popliteus . .	Around the tendon of the popliteus. It may communicate with the superior tibiofibular articulation . . .	Always

Arterial Supply.—Branches from the popliteal, anastomotica magna, external circumflex, and anterior tibial recurrent arteries.

Nerve Supply.—Twigs from the common peroneal (external popliteal), tibial (internal popliteal), anterior crural, and obturator nerves.

Muscles acting on the Joint.—

Flexors—The sartorius, gracilis, biceps, semitendinosus, semimembranosus, popliteus, gastrocnemius, and plantaris.

Extensors—The quadriceps extensor.

External Rotator—The biceps.

Internal Rotators—The popliteus, semitendinosus, semimembranosus, gracilis, and sartorius.

SURFACE ANATOMY OF THE LEG.

From the tuberosity of the tibia the anterior border of the bone should be traced down in its whole length. It is curved in the upper two-thirds, the concavity of the curve being outwards.

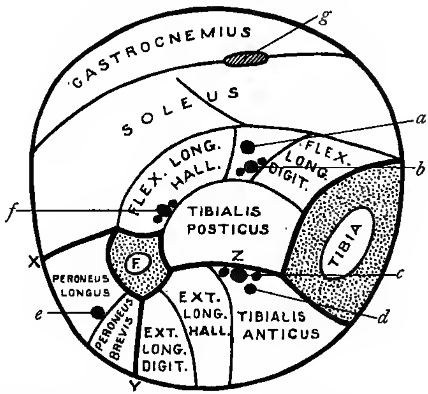
The internal surface of the tibia is subcutaneous below the insertion of the sartorius, and can be followed to the internal malleolus.

Trace the inner border of the tibia from the internal condyle to the malleolus: this border is partly obscured below by the tendon of the tibialis posterior.

Examine the fibula; with the exception of the head, the upper half of the bone is covered with muscles, while the lower half can be palpated beneath the skin. Notice that the fibula occupies a plane posterior to that of the tibia, and also, the curve of the tibia is forwards, while the fibula bends backwards. This should be remembered when amputating through the leg, lest the knife be locked. The fleshy mass in front of the bones

of the leg consists of the tibialis anterior (anticus), extensor longus hallucis, extensor longus digitorum, and the peronæus tertius. A faint sulcus can frequently be distinguished along the outer border of the tibialis anterior; this indicates the position of the anterior tibial vessels and their accompanying nerve. By flexing the ankle joint, the tendon of the tibialis anterior becomes very prominent; those of the extensor longus digitorum are external to the tibialis anterior, and much less distinct.

Fig. 17.—Transverse Section Middle of Right Leg.



a, Posterior Tibial Nerve.
b, Posterior Tibial Vessels.
c, Anterior Tibial Vessels.
d, Anterior Tibial Nerve.
e, Musculo-cutaneous Nerve.
f, Peroneal Vessels.
g, Plantaris.

X Posterior Peroneal Septum.
Y Anterior Peroneal Septum.
Z Interosseous Membrane.

On the back of the leg the gastrocnemius and soleus muscles form an obvious projection, which terminates below in the tendo Achilles. Midway between the inner border of this tendon and the internal malleolus, the pulsations of the posterior tibial artery can be detected.

Aponeurosis of the Leg.—The aponeurosis is attached to all the subcutaneous surfaces of the bones, namely, the head and inner surface of the tibia, the head of the fibula, and the two malleoli.

It forms a strong sheath for the muscles, and has three septa, two of which are attached to the fibula, the anterior and posterior peroneal septa. The third septum lies beneath the soleus, intervening between that muscle and the deep muscles of the back of the leg. This layer of fascia is important, because it roofs over the posterior tibial vessels and nerve.

On examining a transverse section of the leg as in Fig. 17, it will be noticed that there are three well-marked divisions. In front is the anterior tibio-fibular compartment containing the extensor muscles, the anterior tibial vessels, and the deep peroneal (anterior tibial) nerve. The limits of this space are the anterior margin of the tibia, the anterior peroneal septum, and the interosseous membrane. Externally is found the peroneal compartment. It is bounded by the anterior and posterior peroneal septa, and encloses the peronæus longus, peronæus brevis, and the superficial peroneal (musculo-cutaneous) nerve. Lastly, notice the posterior tibio-fibular compartment with the flexor muscles and the posterior tibial vessels and nerve. This area is marked off by the interosseous membrane, the subcutaneous surface of the tibia, and the posterior peroneal septum.

VESSELS OF THE LEG AND FOOT.

Saphena Veins.—The saphena veins are of great surgical interest, as they are so frequently the seat of varicosity.

Internal or Long Saphenous Vein.—This emerges

from the inner part of the venous arch on the dorsum of the foot, and passes up in front of the internal malleolus. It then lies immediately behind the inner border of the tibia, and the inner condyle of the femur, and ascends along the antero-internal aspect of the thigh to enter the femoral vein *via* the saphenous opening.

External or Short Saphenous Vein.—Usually extends from the foot to the popliteal space, but in some cases may join the internal saphenous vein in the upper part of the thigh. It proceeds from the outer part of the arch on the dorsum of the foot, and passes behind the outer malleolus. After travelling upwards along the middle of the calf, the vein pierces the deep fascia of the popliteal space and terminates in the popliteal vein.

The saphena veins often become varicose. Several anatomical factors predispose to this. In such a long column of blood, lateral distension of the walls is very apt to occur, with consequent incompetence of the valves. The superficial position of the veins also tends towards stagnation, for one of the most valuable aids to the venous return is muscular compression (*vis a tergo*). The inner aspect of the lower third of the leg is especially liable to varix, as here the anastomosis between the superficial and deep veins is very imperfect. The passage of these veins through small openings in the deep fascia is said to favour varicosity.

Anterior Tibial Artery.—The position of the anterior tibial artery is indicated by a line from a point, midway between the external condyle of the tibia and the head of the fibula, to the centre of the front of the ankle.

In the upper part, the artery is between the tibialis anterior (anticus) and the extensor longus digitorum; lower down, the artery will be found between the

tibialis anterior and the extensor longus hallucis, the latter crossing to the inner side at the ankle. The deep peroneal (anterior tibial) nerve is superficial to it for some distance, but usually external at its upper and lower parts. Venæ comites accompany the artery.

At first the artery lies deeply on the interosseous membrane; just before its termination, however, it is nearer to the surface and rests upon the tibia.

Ligature of the Anterior Tibial Artery.—The artery may be ligated in any part of its course by an incision along the line of the vessel. In the upper third, the artery will be found on opening up the interval between the tibialis anterior and the extensor longus digitorum. To find the artery in the middle third, first separate the two preceding muscles, and then seek it in the space between the tibialis anterior and the extensor longus hallucis. In the lower third of the leg the anterior tibial is bounded by the tibialis anterior and the extensor longus hallucis.

Dorsalis Pedis Artery.—This artery, the continuation of the anterior tibial, passes from the middle of the front of the ankle to the posterior part of the first interosseous space. It lies on the talus, navicular, and internal cuneiform bones and their ligaments, and is crossed by the dorsal venous arch, and the innermost tendon of the extensor brevis digitorum, the latter forming the surgical guide to the vessel. The artery is situated between the extensor longus hallucis and the extensor longus digitorum, being accompanied on its outer side by the deep peroneal nerve.

Posterior Tibial Artery.—The posterior tibial artery extends along the back of the leg, from the lower border of the popliteus muscle to a point midway between the internal malleolus and the inner border of the tendo Achilles.

In its upper part the artery is placed deeply beneath the muscles of the calf, but at a lower level the vessel is more superficial, and, as it lies between the inner border of the tibia and the tendo Achilles, is covered merely by skin and fascia. The tibial (posterior tibial) nerve is at first internal to the artery, but soon crosses over the vessel to reach the outer side. Venæ comites are present. Remember that the tibial nerve divides into its two plantar branches at a point about three-quarters of an inch above the bifurcation of the artery.

The deep relations are from above downwards, the tibialis posterior (posticus), the tibia, and the ankle-joint. It is comparatively easy to compress the artery in its lower part.

Three branches of the posterior tibial must be mentioned—the peroneal, the medullary to the tibia, and the internal calcanean. The peroneal passes down the leg in the substance of the flexor longus hallucis, whilst the internal calcanean arises beneath the internal annular ligament and supplies the inner aspect of the heel. It is very important not to injure the latter branch when performing Syme's amputation at the ankle.

Ligature of the Posterior Tibial Artery.—The artery may be tied in its lower third, an incision being made half-way between the tendo Achilles and the inner border of the tibia.

In the upper half, where it is deeply placed, the artery is hardly ever ligated except for hæmorrhage. It can, however, be reached in this situation by an incision just behind the inner edge of the tibia. After dividing the soleus and its fascia, the vessel is found resting upon the tibialis posterior.

Another method of exposing the artery is by splitting the superficial calf muscles (Guthrie's ligature).

Plantar Arteries.—Arising from the bifurcation of the posterior tibial, the *internal plantar artery* is of small size and is mainly distributed to the great toe. It will be found between the flexor brevis digitorum and the abductor hallucis.

The *external plantar artery* has a similar origin; it crosses the foot obliquely to reach the base of the fifth metatarsal bone, where it bends inwards and downwards, passing to the posterior extremity of the first interosseous space; here it is joined by the dorsalis pedis, to form the *plantar arch.* In the first part of its course it lies above (in the anatomical position of the body) the flexor brevis digitorum, and then runs between that muscle and the abductor minimi digiti; but its second part (or plantar arch) is suspended from the bases of the metatarsal bones and the plantar interossei muscles.

BONES OF THE LEG.

Anatomical Considerations in Relation to Fracture of the Bones of the Leg.—The upper tibial epiphysis has a tongue-like process on its anterior aspect; into this the ligamentum patellæ is attached. In young athletes sudden traction of the ligament may detach this process, and thus lead to impaired movement (Schlatter's disease).

When both bones of the leg are broken by indirect violence, the tibia is generally fractured in its lower third, and the fibula through its upper half. This is due to the fibula being stronger inferiorly, while the thinnest and most fragile part of the tibia is at the junction of its middle and lower thirds.

Fractures of the tibia are frequently compound, as the bone is subcutaneous throughout its entire length. The lower fragment is drawn backwards and upwards

by the muscles forming the tendo Achilles, whereas the upper fragment is tilted forwards by the ligamentum patellæ, and rotated inwards by the sartorius, gracilis, and the semitendinosus. The nearer the fracture is to the knee-joint, the more marked is the displacement of the proximal fragment.

Fracture of the tibia is more common than that of the fibula, for though a stronger bone, it is more superficial and less protected by muscles than the fibula, and receives more directly violence transmitted to the foot.

Pott's fracture results from violence applied to the abducted and everted limb. When eversion predominates at the moment of injury, the fibula breaks above the base of the malleolus, whereas if abduction is the chief attitude, the bone snaps from two to four inches above the malleolus. In each case the deltoid (internal lateral) ligament is torn, or the internal malleolus avulsed, and frequently the anterior inferior tibio-fibular ligament is ruptured.

When only one bone is broken there is but little displacement, as the other bone acts as a splint.

SURFACE ANATOMY OF THE ANKLE AND FOOT.

Examine the two malleoli; the tip of the external lies three-quarters of an inch behind, and half an inch below that of the internal malleolus.

Other points to be remembered are:—(*a*) the apex of the external malleolus is on a level with the calcaneo-taloid joint; (*b*) the ankle-joint will be found half an inch above the apex of the internal malleolus; (*c*) the epiphyseal line of the fibula is in the same plane as

the ankle-joint; and (*d*) the epiphyseal line of the tibia is found half an inch above the ankle-joint.

Along the inner side of the foot several important bony landmarks are to be defined.

Commencing posteriorly, the internal tubercle of the calcaneus (os calcis) may be felt; one inch below the inner malleolus is the sustentaculum tali. One and a half inches in front of the malleolus notice the tubercle of the navicular; and passing from behind the malleolus to this tubercle is the tendon of the tibialis posterior. About one and a half inches anterior to the tubercle the base of the first metatarsal bone forms a marked ridge, and the rounded head of the bone can be palpated further forwards. The head of the metatarsal bone is frequently unduly prominent, due to the toe having been pushed outwards by badly-fitting boots (hallux valgus). Often the presence of an intermetatarsal bone leads to the condition. This bone occurs in 10 per cent. of individuals (Pfitzner). It is found on the dorsal aspect of the foot, between the internal cuneiform and the first and second metatarsals. In hallux valgus a bursa situated over the metatarso-phalangeal joint generally becomes enlarged, constituting a bunion.

On the external aspect of the foot the calcaneus (os calcis) is subcutaneous, and from this surface a small tubercle (peroneal tubercle) frequently projects. It lies a little below and in front of the external malleolus.

In front of the tubercle is the tendon of the peronæus brevis, which may be traced to its insertion into the base of the fifth metatarsal bone.

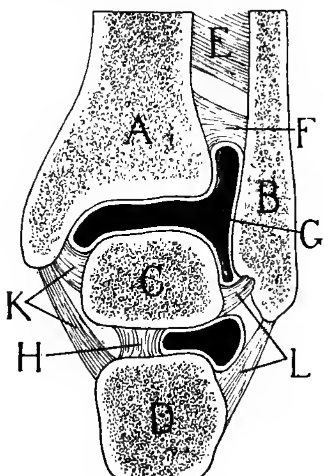
The tendon of the peronæus longus lies behind and below the tubercle, and reaches the groove of the cuboid. It then crosses the sole of the foot as far as

the base of the first metatarsal bone—thus assisting in maintaining the arched form of the foot.

The base of the fifth metatarsal bone forms a distinct projection about two and a half inches in front of the outer malleolus. By inverting the foot the the greater process of the calcaneus can be felt; the extensor brevis digitorum takes origin from it.

Posteriorly, the tendo Achilles is prominent as it passes to be inserted into the calcaneus. Between the upper part of the tendon and the bone a bursa is placed; this sometimes becomes inflamed, and may suppurate.

Fig. 18.—Coronal Section of Ankle and Calcaneo-Taloid Joints. (After Testut.)



A. Tibia.
B. Fibula.
C. Talus.
D. Calcaneus.
E. Interosseous Membrane.
F. Interosseous Ligament.
G. Synovial Cavity of Ankle-Joint.
H. Interosseous Calcaneo-taloid Ligament.
K. Deltoid of Ankle-Joint.
L. Posterior and Middle Fasciculi of Lateral Ligament of Ankle-Joint

FASCIA IN THE REGION OF THE ANKLE.

The deep fascia around the ankle is greatly thickened to form the annular ligaments.

The **Anterior Annular Ligament** consists of two portions—an upper, which passes transversely between the tibia and fibula, and a lower, Y-shaped, the stem of which is on the outer side and attached to the calcaneus; the upper limb goes to the internal malleolus, while the lower limb blends with the plantar fascia. Beneath this, the tendons of the tibialis anterior, extensor longus hallucis, extensor longus digitorum, and peronæus tertius pass, occupying this order from within outwards.

The anterior tibial vessels and the deep peroneal nerve reach the dorsum of the foot under shelter of the annular ligament, lying external to the tibialis anterior, and being crossed superficially by the tendon of the extensor longus hallucis.

Beneath the upper portion of the ligament only the tibialis anterior has a synovial sheath; but beneath the inferior section there are three synovial compartments, one being common to the extensor longus digitorum and the peronæus tertius.

External Annular Ligament.—This band stretches from the external malleolus to the outer surface of the calcaneus, and binds down the tendons of the peronæus longus and brevis, which are included in the same synovial sheath.

Internal Annular Ligament extends from the internal malleolus to the inner process of the calcaneus. Under cover of this ligament the tendons of the tibialis posterior, flexor longus digitorum, and flexor longus hallucis pass to the sole of the foot. Each tendon possesses a separate synovial compartment.

The tibialis posterior lies immediately behind the internal malleolus, and, accordingly, its sheath is in very close relation to the ankle-joint. The posterior tibial vessels and the plantar nerves will be found between the tendons of the flexor longus digitorum and the flexor longus hallucis.

The Plantar Fascia.—The plantar fascia consists of three portions, a central and two lateral. The central portion, which is very thick and somewhat triangular, passes from the calcaneus to the metatarso-phalangeal joints, and its arrangement is very similar to that in the hand. It is firmly adherent to the superficial layer of muscles of the sole. This fascia assists in maintaining the arch of the foot, and is one of the structures which yield in flat-foot.

In *talipes varus* the internal band of the plantar fascia becomes thickened and contracted. This contraction is only an adaptive shortening, occurring secondarily to the deformity of the foot.

In *pes cavus*, where the foot is abnormally arched, the plantar fascia is very markedly contracted, and may require complete division. This is most easily undertaken at its attachment to the calcaneus.

CHIEF JOINTS OF THE FOOT.

Ankle.—The articular surfaces entering into the ankle-joint are those of the lower extremities of the tibia and fibula, and the superior, external, and internal surfaces of the talus (astragalus). On examining the tibio-fibular socket it will be noticed to be wider in front than behind, and also that it is augmented by the distal ligament of the external malleolus. Four ligaments unite to form an articular capsule for the ankle—they are named anterior, posterior, lateral

(external lateral), and deltoid (internal lateral). The anterior and posterior are feeble bands, passing from the lower margin of the tibia to the talus. Both the deltoid and the lateral ligaments, however, are very powerful. The lateral consists of three distinct fasciculi which radiate from the external malleolus to the outer aspect of the neck of the talus, the outer surface of the calcaneus (os calcis), and the os trigonum of the talus. The deltoid ligament stretches from the internal malleolus to the tubercle of the navicular, the calcaneo-navicular ligament, the talus, and the sustentaculum tali of the calcaneus.

Synovial Membrane.—This invests the articular capsule, and lines the gap between the lower ends of the tibia and fibula. The presence of fluid in the ankle-joint obliterates the depressions which lie in front of, and behind, the malleoli.

Movements.—Flexion and extension occur at the ankle. It is a ginglymus joint and "it is doubtful whether lateral movement can be obtained by any natural movement of the foot" (Hepburn). *Flexors*—the tibialis anterior, peronæus tertius, and the long extensors of the toes. *Extensors*—the tibialis posterior, peronæus longus, peronæus brevis, long flexors of the toes, and the tendo Achilles.

Mid-Tarsal Joint.—Formed by the calcaneus and talus behind, with the cuboid and navicular in front. It corresponds to a line drawn across the foot, from a point immediately behind the tubercle of the navicular to a point midway between the external malleolus and the base of the fifth metatarsal bone.

Through this joint the foot is removed in Chopart's amputation.

The movements occurring at the mid-tarsal joint are

inversion and eversion. The invertors are the tibialis anterior and posterior, while the three peronæi serve as evertors.

Table of the Invertors and Evertors.

Muscle	Chief Origin	Insertion	Nerve Supply
Tibialis anterior	Outer condyle and upper two-thirds of outer surface of tibia and from interosseous membrane	Inner side of internal cuneiform, and base of 1st metatarsal	Deep peronæal
Tibialis posterior	Internal surface of fibula; posterior surface of tibia, and from interosseous membrane	Tubercle of navicular; to all remaining tarsals except talus; and to bases of three middle metatarsals	Tibial
Peronæus longus	From head and upper two-thirds of the outer surface of fibula	Outer side of internal cuneiform, and base of 1st metatarsal bone	Superficial peronæal
Peronæus brevis	Lower two-thirds of outer surface of fibula	Outer side of base of 5th metatarsal bone	Superficial peronæal
Peronæus tertius	Arises along with extensor longus digitorum from anterior surface of fibula	Inner side of base of 5th metatarsal bone	Deep peronæal

Tarso-Metatarsal Joint.—This joint is represented by a curved line, with its convexity towards the toes, extending from behind the tuberosity of the fifth metatarsal bone to a point immediately behind the proximal extremity of the first metatarsal bone. The joint-line is very irregular because the base of the second metatarsal bone projects backwards between the internal and external cuneiform bones. At the tarso-metatarsal joint the anterior part of the foot is removed in Hey's or Lisfranc's amputation.

The *metatarso-phalangeal* articulations are placed about an inch behind the webs of the toes. Their ligaments, and also those of the inter-phalangeal joints, follow the same plan as the corresponding joints of the hand.

Synovial Membranes.—In the foot there are usually six distinct synovial membranes :—

Table of Synovial Membranes.

Name	Situation
Posterior talo-calcaneal .	Between the calcaneus and the talus, behind the interosseous ligament.
Anterior talo-calcaneo-navicular	In front of the interosseous ligament, and between the talus and the navicular.
Calcaneo-cuboid . .	Between the calcaneus and the cuboid.
Cuboideo-metatarsal . .	Separating the cuboid from the bases of the 4th and 5th metatarsals.
Cuneo-metatarsal . .	Between the internal cuneiform and the base of the 1st metatarsal.
Anterior tarsal . .	Passes between the navicular, cuboid, cuneiforms, and the bases of the 2nd and 3rd metatarsals.

The anterior tarsal synovial membrane is the largest and most important of all, for while tarsal disease

usually commences in the bones, the synovial membranes quickly become secondarily affected. If the disease arises in the calcaneus it may remain localised for a very considerable time, owing to the limitation of the synovial membranes in relation to that bone; but if it takes origin in the navicular or cuneiform bones, it will rapidly extend through the anterior part of the tarsus.

THE ARCHES OF THE FOOT.

The foot is arched in two directions, longitudinally and transversely. The transverse arch gives elasticity to the anterior part of the foot, and is best marked opposite the tarso-metatarsal joints. Surgically, it is less important than the longitudinal arch.

When a person stands erect, the foot rests upon what is termed the "anatomical tripod." The posterior pier is formed by the heel; the antero-internal pier by the heads of the three inner metatarsals; and the antero-external pillar by the two outer metatarsals. Part of the inner border and sole do not touch the ground, but form an arch along which the skin is thin and delicate. This arch may be increased, diminished, or entirely absent. If it be markedly increased, *pes cavus* results. In this, the outer border of the foot does not touch the ground, and accordingly the weight of the body is borne by the calcaneus and the heads of the metatarsal bones.

When the arch is lost, as in *pes planus* (flat-foot), the entire sole is in contact with the ground.

Examine the longitudinal arch from the inner aspect of the foot. The posterior pier or pillar is stable, and is formed by the calcaneus; the anterior pillar is more resilient and springy, being made up of

the navicular, internal cuneiform, and the first metatarsal.

The keystone of the arch is the talus. This bone rests mainly on the calcaneus, to which the weight of the limb is chiefly transmitted. The head of the talus, however, is not completely supported by the calcaneus, as a portion of it overhangs the interval between the latter bone and the navicular. In this position it is closely applied to the upper surface of the inferior calcaneo-navicular ligament, which extends from the sustentaculum tali to the navicular. In turn, the tendon of the tibialis posterior supports the ligament. If this ligament becomes stretched, the head of the talus is allowed to sink, thus destroying the arch. Accordingly, in flat-foot the head of the talus forms a marked projection on the inner side of the foot; its under surface, which is encrusted with cartilage, is subjected to pressure, and is frequently the seat of intense pain.

Other structures in the foot assist in maintaining the integrity of the arch: such as the remaining plantar ligaments and the tendon of the peronæus longus; while the plantar fascia and the short plantar muscles, extending from one extremity of the arch to the other, act as a tie.

A recognition of the part played by the muscles, in supporting the arch of the foot, led to the adoption of the method of treating flat-foot by means of tip-toe exercises.

In *talipes valgus* the same deformity occurs as in flat-foot, but the deep muscles of the back of the leg are frequently paralysed while the peronæi are rigidly contracted, and accordingly the foot is everted.

In *talipes varus* the inner border of the foot is drawn upwards by the tibial muscles (anterior and posterior).

The heel is usually elevated also by the tendo Achilles (*equino-varus*). That part of the foot which lies in front of the mid-tarsal joint is bent inwards, the navicular being thus approximated to the internal malleolus; the head of the talus is curved inwards at the neck, so that instead of being directed forwards it is directed forwards and inwards, in order to articulate with the displaced navicular. In addition, the lower third of the tibia is rotated inwards. The ligaments and fascia on the inner border of the foot are much contracted, while the foot rests on the outer border, or even on the dorsal surface in extreme cases.

In *talipes equinus* the heel is drawn upwards by the tendo Achilles. The talus is displaced downwards and forwards, and projects on the dorsum of the foot.

Talipes or *pes calcaneus* is very rare. In the congenital form the anterior part of the foot is dorsi-flexed at the ankle-joint, owing to the rigid contraction of the muscles of the front of the leg.

To remedy these deformities the contracted tendons often require division. The tendons most frequently divided are those of the tibialis anterior and posterior, the tendo Achilles, and, more rarely, the peronæi. The position of these tendons has been previously indicated.

The *tibialis anterior* may be divided on the dorsum of the foot, between the ankle and its attachment to the internal cuneiform bone. The knife is introduced from the fibular side to avoid the dorsalis pedis artery.

The *tibialis posterior* is usually severed behind the tibia, an inch above the inner malleolus. In the normal foot the tendon may be divided between the malleolus and the tubercle of the navicular; but in talipes equino-varus (for which the operation is usually performed) this is difficult, owing to the approximation of the

navicular to the malleolus, which occurs in that deformity.

The *tendo Achilles* is generally divided one inch above its insertion into the os calcis. Care should be taken when cutting the tendo Achilles, or tibialis posterior, lest the posterior tibial artery be wounded.

The *peronæus longus* and *peronæus brevis* are incised one and a half inches above the external malleolus; the knife should be passed beneath the tendons, and the section made towards the skin (Tubby).

SECTION III

THE HEAD AND NECK

THE SCALP

WITH the exception of the temporal region, the scalp comprises five distinct strata—namely, integument, superficial fascia, aponeurosis of the occipito-frontalis muscle, the sub-aponeurotic lymphatic space, and the pericranium, which forms the immediate investment of the calvaria.

The skin of the scalp is very tough, and is brought into intimate connection with the occipito-frontalis by means of the superficial fascia. In this fascia, the fibres are directed at right angles to the skin and muscle, an arrangement which also holds good in the palms of the hands, and the soles of the feet. The intervals between the fibres are occupied by pellets of fat, and lodge the main arteries and the sensory nerves. It must be remembered that the walls of the blood-vessels are adherent to the strands of superficial fascia, thus preventing the necessary contraction and retraction of the vessels when severed, and hence the difficulty experienced in controlling hæmorrhage in this situation. If suppuration occur in the superficial fascia it is usually localised, due to the strong septa present.

The occipito-frontalis comprises four small muscular bellies united by an extensive tendon—the epicranial aponeurosis. At the sides it is prolonged over the surface of the temporal fascia as far as the zygoma.

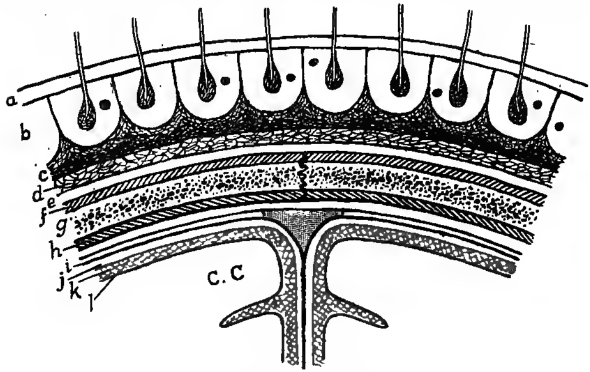
The sub-aponeurotic space consists of a loose connective-tissue meshwork intervening between the occipito-frontalis and the pericranium; it acts as a lymphatic bursa for the movable portion of the scalp. Pus formed in this territory diffuses widely; the extent of the suppuration is only limited by the attachments of the epicranial aponeurosis. Another danger is that the infection can spread along the emissary and diploic veins to the meninges and venous sinuses.

The pericranium is feebly attached to the cranial bones except in the vicinity of the sutures, and here it comes into continuity with the dura mater by means of the sutural membrane. Accordingly, if pus or blood collect beneath the pericranium the effusion is confined to one bone. The pericranium has little or no osteogenetic function, the physiological periosteum being the dura mater; the blood-vessels of the latter likewise form the chief source of nourishment for the cranial bones.

In avulsion of the scalp, the plane of division occurs in the layer of loose connective tissue; if the separation be incomplete, the flap, unless severely damaged, may be safely replaced without risk of sloughing, as the principal arteries lie in the superficial fascia.

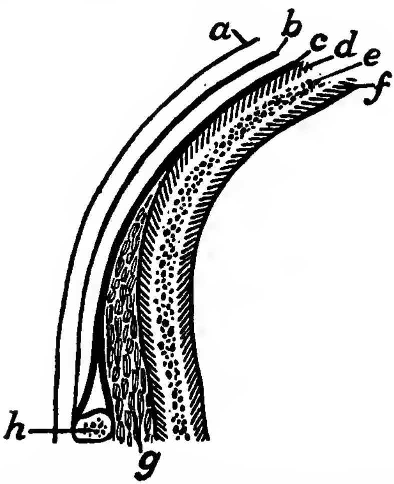
The temporal region is one of great importance for (i) it is the common site for trephining in meningeal hæmorrhage; (ii) it affords a ready means of access to the Gasserian ganglion; and (iii) it is the area through which decompression operations for irremovable cerebral tumours are performed. The main layers of this part of the scalp are integument; superficial fascia, containing the superficial temporal vessels; superficial temporal fascia; deep temporal fascia; temporal muscle and pericranium. The superficial temporal fascia is of a somewhat delicate texture, whereas the deep fascia possesses great strength. Both extend from the temporal ridge

FIG. 19 (*a*).—CORONAL SECTION OF THE SCALP AND MENINGES.



a. Skin; *b*. Dense connective tissue with hair follicles and blood-vessels; *c*. Epicranial aponeurosis; *d*. Subaponeurotic space; *e*. Pericranium and subpericranial space; *f*. Outer table; *g*. Diploe; *h*. Inner table; *i*. Endocranial layer of dura; *j*. Supporting layer of dura; *k*. Arachnoid; *l*. Pia mater.

FIG. 19 (*b*)—CORONAL SECTION OF TEMPORAL REGION.



a. Skin; *b*. Epicranial aponeurosis; *c*. Pericranium forming deep temporal fascia; *d*. Outer table; *e*. Diploe; *f*. Inner table; *g*. Temporal muscle; *h*. Zygoma.

to the zygoma, the deep fascia, however, dividing when near this process, to become attached to its outer and inner borders. Other points in which the scalp of the temporal region differs from the remainder are (*a*) the skin is thinner and is not so tightly bound down to the deeper structures; (*b*) the superficial fascia is less dense and contains more fat; (*c*) the coats of the blood-vessels are only slightly adherent to the fibrous septa; and (*d*) the pericranium is more firmly fixed to the bone. The last fact explains why a sub-pericranial hæmatoma cannot occur in this area.

Nerve-Supply.—The motor supply is derived from the facial nerve. The sensory nerves spring from two sources, namely, the trigeminal or fifth cranial nerve and the cervical nerves; as previously mentioned, the main trunks ramify in the superficial fascia before reaching the integument. It will be seen from an examination of Fig. 20 that the trigeminal supplies the anterior half of the scalp, and the cervical nerves the posterior half.

Table of the Sensory Nerves.

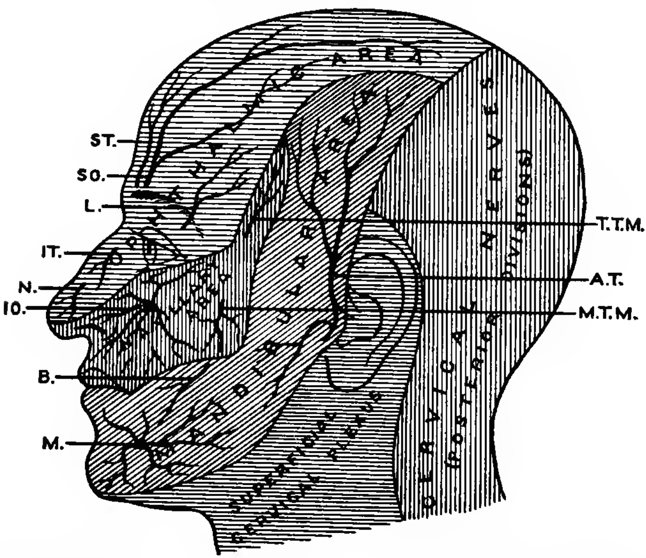
Nerve	Source	Situation	Area Supplied
Supra-orbital	Frontal branch of ophthalmic division of trigeminal	Junction of middle and inner thirds of superior orbital margin	Upper eyelid and forehead. The nerve can be traced backwards to the lambdoidal suture.
Supra-trochlear		Midway between supra-orbital and mid-line of forehead	Root of nose, inner canthus, and mesial aspect of forehead.

Nerve	Source	Situation	Area Supplied
Orbital	Superior maxillary division of trigeminal	Immediately behind malar tubercle	Temporal region.
Auriculo-temporal	Inferior maxillary division of trigeminal	Slightly in front of tragus of ear	Anterior surface of pinna and temporal region.
Great auricular	Anterior primary divisions of 2nd and 3rd cervicals	Over mastoid process	Posterior surface of pinna and mastoid region.
Small occipital	Anterior primary division of 2nd cervical	Midway between external occipital protuberance and mastoid process	Occipital region.
Great occipital	Posterior primary division of 2nd cervical	About 1 inch to outer side of external occipital protuberance	Occipital region.

Blood-vessels.—Both the external and the internal carotid arteries transmit blood to the scalp, the former through the superficial temporal, posterior auricular, and occipital branches, and the latter by means of the frontal and supra-orbital branches of the ophthalmic. A remarkably free anastomosis occurs between these vessels and those of the opposite side; hence the futility of ligating the external carotid as a means of treating cirsoid aneurysm of the superficial temporal.

The frontal and supra-orbital arteries closely accompany the supra-trochlear and supra-orbital nerves; the posterior auricular and the nerve of the same name lie deeply in the sulcus between the pinna and mastoid; the occipital enters the scalp with the great occipital nerve on its outer side; and lastly, the superficial temporal crosses the zygoma (against which it may be easily compressed), immediately in front of the tragus, the auriculo-temporal nerve lying posterior to the artery.

Fig. 20.—The Sensory Areas of the Head. (After Gerrish and Testut.)



ST. Supra-trochlear.
SO. Supra-orbital.
L. Lacrimal.
IT. Infra-trochlear.
N. Nasal.
IO. Infra-orbital.
B. Buccal.
M. Mental.
T.T.M. Temporal Branch of orbital.
A.T. Auriculo-temporal.
M.T.M. Malar Branch of orbital.

Beneath the pericranium the scalp vessels communicate with the meningeal vessels along the sutural membrane.

The veins of the scalp must be studied, as they are intimately connected with the blood sinuses by means of the emissary and diploic veins.

Table of the Scalp Veins.

Vein.	Termination.
Frontal . . . Supra-orbital . .	Unite to form the angular—the commencement of the facial vein.
Superficial temporal.	Joins the internal maxillary in the parotid gland, the temporo-maxillary resulting.
Posterior auricular .	Unites with the posterior division of the temporo-maxillary to form the external jugular.
Occipitals . . .	Open into the deep cervical vein, a tributary of the vertebral.

THE CRANIUM.

The cranium is ovoid in shape, broader behind than in front, and with the antero-posterior axis greater than the transverse. In healthy adult skulls the thickness averages one-fifth of an inch. This figure is exceeded at the inion or external occipital protuberance, the mastoid process, the glabella, the frontal eminence, and the parietal eminence. The thin areas are the squamosal, the cerebellar fossæ, and along the lines of the middle meningeal vessels. During infancy and old age the cranium is more delicate than at other periods. Of the two tables, the outer is thick and elastic; while the inner is thin, inelastic, and brittle, hence the term "vitreous" frequently applied to it. Extreme violence may fracture the inner table without apparently damaging the outer. As the bones of the cranium possess few osteoblasts, repair is usually brought about

by fibrous tissue. The diploë, or red bone marrow, separates the tables; it is only slight in amount before the tenth year, and tends to become absorbed in old age. It is very vascular, receiving branches from both the pericranial and the meningeal arteries. The issuing veins are collected into four groups.

Table of the Diploic Veins.

Vein.	Termination.
Frontal . . .	Supra-orbital vein.
Anterior temporal .	Deep temporal vein.
Posterior temporal .	Superior petrosal sinus.
Occipital . . .	Transverse (lateral) sinus

The developmental errors of the cranium brought before the notice of the surgeon are usually found in the occipital region; less frequently at the root of the nose. They take the form of hernial protrusions, consisting either of meninges and cerebro-spinal fluid (a meningocele), brain substance and meninges (an encephalocele) or even brain substance, together with a portion of the lateral ventricle (a hydrencephalocele). In syphilitic and rickety children the skull bones often exhibit areas of defective ossification, a condition known as craniotabes.

Meningeal Arteries.—The anterior cranial fossa is supplied by branches of the ethmoidal vessels; the middle fossa by branches of the internal maxillary (small and middle meningeal), ascending pharyngeal, and internal carotid; and the posterior fossa by branches of the ascending pharyngeal, occipital, and vertebral.

The middle meningeal is the largest branch of the first part of the internal maxillary. It arises between the internal lateral ligament and the condyle of the

mandible, passes under cover of the external pterygoid, and between the roots of the auriculo-temporal nerve, to the foramen spinosum, and thus enters the middle cranial fossa. Here it ascends for a short distance in a groove on the great wing of the sphenoid and divides into anterior and posterior branches, of which the anterior is the larger and the more important. The anterior branch ascends in the groove (sometimes a canal), upon the great wing of the sphenoid, with a slight forward convexity as far as the anterior inferior angle of the parietal. From this point the artery passes upwards and backwards, more or less parallel with the anterior border of the parietal, giving off branches which are directed backwards. The artery corresponds with points, one, one and a half, and two inches, both above the zygoma and behind the external angular process. The posterior branch is not so important; it runs backwards and upwards over the squamosal towards the parietal eminence (Fig. 21).

Occasionally the middle meningeal possesses an additional branch (the orbital), which traverses the sphenoidal fissure. It is due to the persistence of a fœtal vessel, the stapedial artery. When tying the middle meningeal, the ligature should be applied above the level of this branch in order to avoid reflux hæmorrhage from the vessels of the orbit.

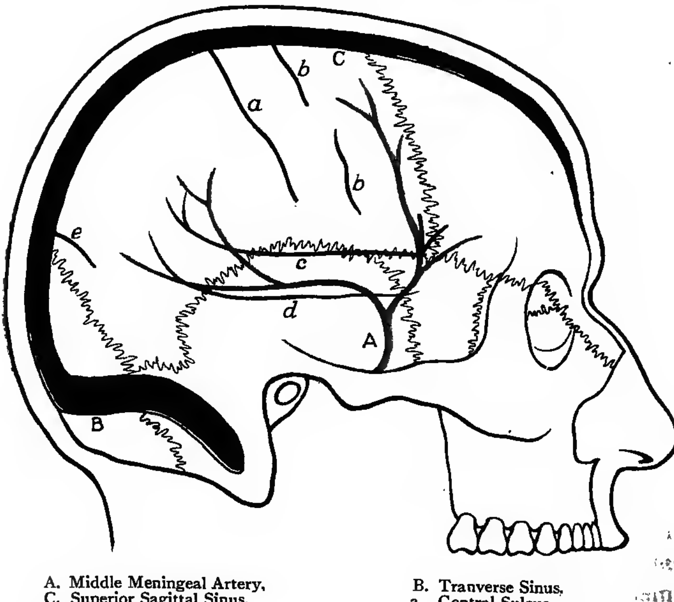
Accompanying the middle meningeal are two venæ comites; they intervene between the artery and the bone. It has been shown by Wood-Jones that they occupy the grooves upon the inner table of the cranium formerly held to lodge the artery.

Cerebral Meninges.—*Dura mater*—Two strata unite to form the dura mater; they possess different functions. The outer or endocranial layer serves as the internal periosteum for the cranial bones. It is adherent

to the base of the skull, and to the vault along the lines of the sutures; elsewhere the membrane is readily stripped off by extravasated blood.

The inner or supporting layer provides several stout laminæ, namely, the falx major, falx minor, tentorium cerebelli, diaphragma sellæ, and a partition stretching

Fig. 21.—Cranio-Cerebral Topography.



A. Middle Meningeal Artery.
C. Superior Sagittal Sinus.
b. Precentral Sulci.
d. Parallel Sulcus.
B. Tranverse Sinus.
a. Central Sulcus.
c. Lateral Cerebral Sulcus.
e. Ext. Parieto-occipital Sulcus.

over the Gasserian ganglion, forming the cavum Meckelii.

Between the dura mater and the arachnoid is the sub-dural space; it contains a small quantity of lymph.

Pia-arachnoid.—For surgical purposes the arachnoid

and the pia-mater are looked upon as one membrane—the pia-arachnoid. The pial portion is very vascular, and has a most intimate relation both to the exterior and the interior of the brain. It dips into every cerebral, and into the main cerebellar sulci; it forms the velum interpositum which roofs over the third ventricle, and lastly its processes accompany the cerebral vessels into the brain as their perivascular sheaths. Bearing in mind these facts, it is easy to understand why encephalitis is always associated with lepto-meningitis.

With the exception of the great longitudinal and the lateral (Sylvian), the arachnoid does not project into the fissures.

The presence of the pia-arachnoid membrane renders the recognition of the individual sulci a matter of great difficulty in the living.

The sub-arachnoid space is of prime importance. It consists of numerous delicate trabeculæ of gossamer-like texture containing cerebro-spinal fluid. At certain intervals the fluid forms special collections termed cisterns. Two of these are found at the base of the brain (*a*) the *cisterna pontis* (containing the vertebral and basilar arteries), and (*b*) the *cisterna basalis* (containing the main trunks of the circle of Willis). The largest collection, however, is the *cisterna cerebello-medullaris* (*magna*). It covers-in the gap between the medulla oblongata and the inferior surface of the cerebellum.

Cerebro-spinal fluid.—The total quantity of cerebro-spinal fluid found in the ventricles of the brain, and in the sub-arachnoid spaces of the brain and spinal cord is about 100-130 ccs. The fluid is transparent, alkaline in reaction, and has a specific gravity of 1006-1008. It contains a large quantity of sodium chloride, and

traces of protein, phosphates, carbonates, urea, and dextrose.

The fluid is secreted by the choroid plexuses of the ventricles. These plexuses are vascular tufts of connective-tissue covered by a layer of delicate epithelium —the ependyma. From the lateral ventricles the fluid goes into the third ventricle by way of the foramina of Monro; from the third into the fourth through the aqueduct of Sylvius, and from the fourth into the cisterna cerebello-medullaris, *via* three slit-like apertures in the pial membrane covering this ventricle. The central opening is termed the foramen of Magendie, and the two lateral ones, the foramina of Key and Retzius. Most of the fluid passes into the blood sinuses of the dura mater, especially the superior sagittal (longitudinal), probably through the medium of the Pacchionian bodies.

After an attack of basal meningitis, adhesions may obliterate the foramina of Magendie and Key and Retzius, and thus lead to internal hydrocephalus.

Venous Blood Sinuses.—The venous blood sinuses lie between the two layers of the dura mater; they are divided into single and paired. The single sinuses are the superior sagittal, inferior sagittal, straight, circular, and basilar; the paired ones are the transverse, superior petrosal, inferior petrosal, cavernous, occipital, and spheno-parietal. At several situations the sinuses communicate with the veins on the exterior of the cranium by means of the emissary veins. The chief facts to remember regarding the emissary veins are given in the accompanying table.

Table of the Emissary Veins.

Emissary Vein.	Course.	Cerebral Blood Sinus.	Extra-Cranial Termination.
Nasal	Through foramen cæcum.	Superior sagittal.	Nasal mucous membrane.
Ophthalmic	Joins inferior division of ophthalmic vein.	Cavernous.	Frontal or angular vein.
Parietal	Through parietal foramen, near lambda.	Superior sagittal.	Scalp veins.
Mastoid	Through mastoid foramen.	Transverse.	Posterior auricular or occipital veins.
Condyloid .	Through anterior and posterior condyloid foramina.	Transverse.	Occipital veins.
Carotid .	Through carotid canal.	Cavernous.	Internal jugular vein.
Pterygoid .	Through foramen ovale and spinosum.	Cavernous.	Pterygoid and pharyngeal plexus. The former communicates with the facial by means of the deep facial.

The Superior sagittal sinus occupies the upper border of the falx major, and extends from the foramen cæcum, where it communicates with the nasal emissary vein, to the internal occipital protuberance. Near the latter point it presents a dilatation, the torcular Herophili. At first the sinus lies in the mesial plane, but on reaching the parietal bone it is directed a little to the right. Narrow at its origin, the calibre of the sinus greatly increases as it passes backwards. The vessel is

triangular on section, the apex pointing towards the brain (see Fig. 19). The parasinoidal sinuses or lacunæ open into it; they are most numerous in the parietal region. Projecting into the lacunæ are the Pacchionian bodies (arachnoidal villi). From before backwards the superior sagittal sinus grooves the frontal, the two parietal, and the occipital bones.

The inferior sagittal sinus runs in the lower border of the falx major. It terminates by uniting with the vein of Galen, which drains the interior of the brain, to form the sinus rectus (straight sinus).

The sinus rectus is found at the junction of the falx major and the tentorium cerebelli. It is triangular on section with the apex directed upwards. Passing backwards between the occipital lobes of the cerebrum and the cerebellum, it terminates at the internal occipital protuberance.

The cavernous sinuses.—Each commences opposite the anterior clinoid process as the continuation of the ophthalmic vein, and flanking the sella turcica of the sphenoid, ends at the posterior clinoid process by dividing into the superior and inferior petrosals. The free communication of the cavernous sinus with the ophthalmic vein explains why thrombosis of the sinus is followed by exophthalmos, and by œdema of the eyelids. Traversing the outer wall are the oculo-motor, the trochlear, and the ophthalmic and superior maxillary divisions of the trigeminal nerves, while on the inner wall are the abducens nerve, and the internal carotid artery. The circulation through the cavernous sinus is materially assisted by the pulsations of the internal carotid.

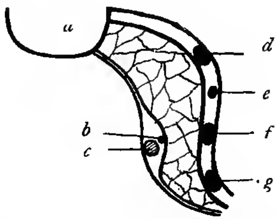
The sinus is apt to be damaged by fractures of the middle cranial fossa. Frequently the internal carotid is ruptured by the injury, thus producing an arterio-venous

aneurysm. Uniting the two cavernous sinuses is a venous plexus called the *circular sinus.*

The spheno-parietal sinuses will be found along the free borders of the lesser wings of the sphenoid. They are tributaries of the cavernous sinuses.

The superior and inferior petrosal sinuses run along the upper and lower borders of the petrous portion of the temporal. The superior sinus terminates in the transverse sinus; the inferior one proceeds through the anterior compartment of the jugular foramen to join the

Fig. 22.—Coronal Section of Cavernous Sinus.



a. Pituitary fossa (sella turcica)
b. Abducens nerve.
c. Internal carotid artery.
d. Oculo-motor nerve.
e. Trochlear nerve.
f. Ophthalmic division of trigeminal nerve.
g. Superior maxillary division of trigeminal nerve.

internal jugular vein. Connecting the inferior petrosals is the *basilar sinus.*

The occipital sinuses usually join the lower part of the transverse sinuses to the torcular Herophili; in the majority of cases they form a common trunk previous to reaching the torcular. The vessels lie between the two layers of the falx cerebelli.

The transverse sinuses.—The right sinus is a continuation of the superior sagittal, the left, of the straight sinus. Owing to the close proximity of the ear and mastoid, thrombosis of the transverse sinus is a frequent complication of chronic otitis media, and as the right

sinus extends further forwards than the left, thrombosis is more common on the right side.

Each transverse sinus passes horizontally outwards, grooving the occiput along the lines of attachment of the tentorium cerebelli, to reach its highest point opposite the asterion (a point one and a half inches behind, and half an inch above the centre of the external auditory meatus), where it indents the posterior inferior angle of the parietal. The sigmoid portion of the sinus is in relation to the mastoid region of the temporal and the occipital, and has a very complex course. It is first directed vertically, then transversely, with a downward convexity, and lastly, passes upwards and outwards to reach the jugular foramen. Here the sinus dilates, forming the jugular bulb, but narrows again as it emerges through the posterior compartment of the foramen as the internal jugular vein.

Were it not for these anatomical arrangements, the effect of a deep inspiration on the great veins of the neck would be so to aspirate the venous channels of the brain as to cause faintness, or momentary unconsciousness (White).

Arterial Supply of the Brain.—The arterial supply of the brain is derived from the circle of Willis, an anastomosis situated in the cisterna basalis. Two distinct sets of vessels pass to the cerebrum from this circle: (a) *cortical* which course over the cerebral surface, ramify in the pia mater, and there communicate with each other; (b) *basal* which arise in groups, and penetrate the inferior surface of the cerebrum to terminate in the basal ganglia, and the interior of the brain. The basal branches do not anastomose.

The arteries comprising the circle are two anterior cerebrals, two middle cerebrals, two posterior cerebrals two posterior communicating, and the anterior com-

municating. How do these arise? The vertebral arteries, when they reach the lower border of the pons, unite as a single trunk, the basilar. This grooves the pons, and on its upper border divides into the posterior cerebrals. Each internal carotid contributes three branches to the circle, namely, the middle cerebral, anterior cerebral, and a branch to anastomose with the posterior cerebral—the posterior communicating. Lastly, a small transverse channel, the anterior communicating, connects the anterior cerebrals.

The chief branches of the vertebral are—meningeal, spinal, bulbar, and posterior inferior cerebellar. Arising from the basilar before it terminates as the posterior cerebrals are the pontine, auditory, anterior inferior cerebellar, and superior cerebellar branches.

Cranio-cerebral Topography.—The surgeon is principally concerned with the external surface of the cerebral hemispheres, hence we shall confine our attention to this.

Frontal lobe.—The frontal lobe presents anteriorly the frontal pole; behind, it is limited by the sulcus centralis (Rolando), below, by the sulcus lateralis (Sylvius), and above, by the superior margin of the cerebrum. Four gyri are found, namely, superior, middle, inferior, and precentral. Of these the last is of chief importance as it contains the main motor centres for the opposite side of the body. The posterior third of the left inferior frontal convolution (Broca's area) was formerly held to be the motor speech centre; considerable doubt has been thrown upon its claim by Marie and his pupils.

Have the superior and middle frontal gyri any special function, or are they merely "silent" areas? Clinical observation suggests that in right-handed persons, the left superior and middle frontal contain the centres for the conscious initiation of fine movements, such as

touching the nose with the tip of the finger. Loss of this function is termed "apraxia."

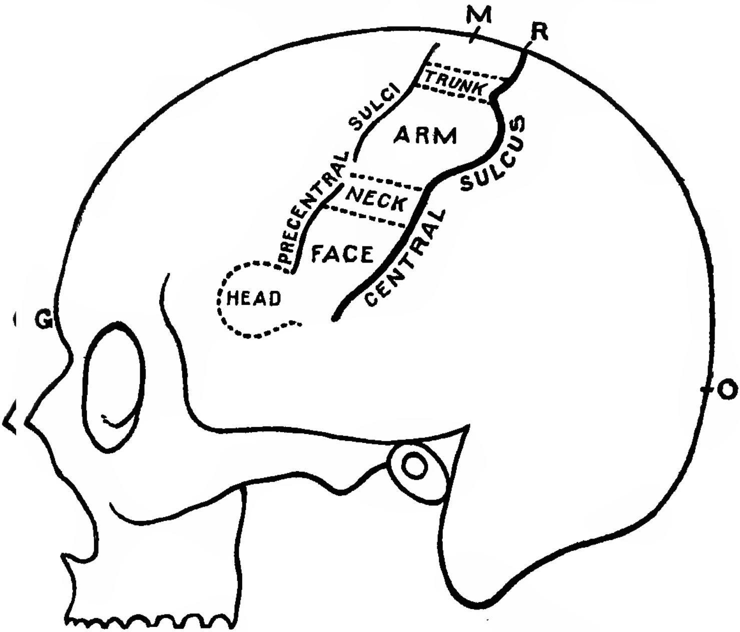
Central sulcus and motor area (see Fig. 23). The central sulcus is directed downwards and forwards from the great longitudinal fissure of the brain at an angle of 71·5° (Cunningham). A line three and three-eighth inches long, drawn from a point half an inch behind the middle of the glabella-inion line, and carried towards the tubercle of the zygoma, will, for all practical purposes, represent the fissure. Anatomically, however, the sulcus is somewhat sinuous in outline, presenting at the junction of its upper and middle thirds, a well-marked recess with the convexity backwards. The two limbs of the recess are termed the superior and inferior genua. The centres for the *leg* are situated in the precentral gyrus above the superior genu (they also encroach upon the mesial surface—the paracentral lobule); those for the *trunk* are found opposite the superior genu; the *arm* centres occupy the recess between the genua, and also abut against the inferior genu. Below the inferior genu are the centres for the *neck* and the *face*, the former being on a higher level than the latter.

Lateral cerebral sulcus (Sylvius).—The bifurcation of the lateral cerebral sulcus lies opposite the pterion, which is placed one and half inches behind the external angular process of the frontal bone, and one and a half inches above the zygoma. The posterior limb of the fissure corresponds to a line drawn from the pterion to a point half an inch below the most prominent part of the parietal eminence.

Parietal lobe.—In *front*, the parietal lobe is limited by the central sulcus, *below* by the posterior limb of the lateral sulcus, and an artificial line carried backwards, and *posteriorly* by an artificial line drawn from the

external parieto-occipital fissure to the pre-occipital notch (a groove on the lower border of the cerebrum one and a half inches in front of the occipital pole). The gyri on the external surface of the parietal lobe are postcentral, superior, and inferior; the last is divided from before backwards into three areas—supra-marginal

Fig. 23.—Diagram of the Central Sulcus and Motor Area.



G. Glabella
O. Inion.

M. Mid point.
R. Rolandic point.

angular, and postparietal. With regard to the function of the parietal cortex, it is entirely sensory in character, the postcentral convolution forming the receiving station for cutaneous sensibility. The order of the centres corresponds to that of the motor area, *i.e.* leg, arm, and

face, from above downwards. Until recently the left angular gyrus was regarded as the visual speech centre, but it is exceedingly doubtful if any such special function can be assigned to it.

Occipital lobe.—The external surface presents three convolutions, namely, superior, middle, and inferior. On the mesial aspect of the lobe is found the calcarine fissure, and around it are grouped the centres for vision. The *left* half of each retina is represented in the *left* occipital cortex, and the *right* half of each retina has its centre in the right occipital cortex; the fovea centralis of each retina, however, has a bilateral representation. The centres for the upper half of the retina are situated above the calcarine fissure, while those for the lower half lie below the fissure.

Temporal lobe.—This lobe is bounded above by the posterior limb of the lateral sulcus, and the artificial line carried backwards from it. The apex of the lobe is called the temporal pole. Three gyri are present—superior, middle, and inferior; they are separated from each other by the superior and inferior temporal sulci. The superior temporal sulcus is often termed the parallel fissure. In right-handed individuals the *auditory speech centre* lies in the posterior third of the left superior and middle convolutions.

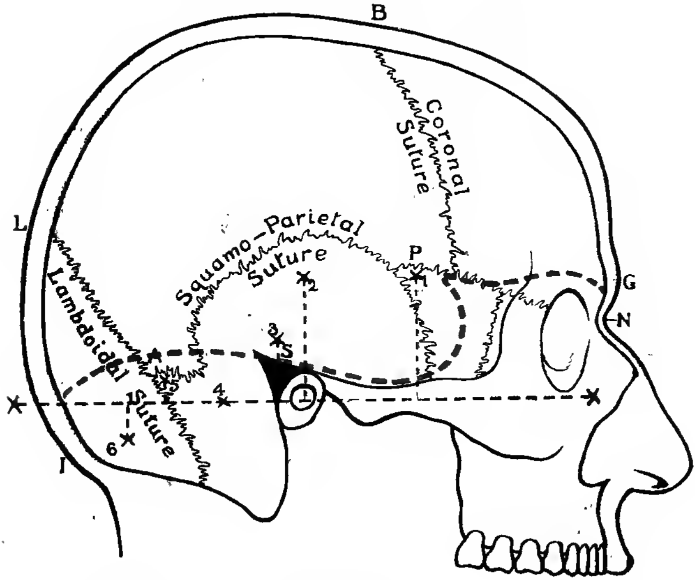
Parieto-occipital and Parallel Fissures.—To mark out these sulci, first identify the lambda; it is situated two and a half inches above the external occipital protuberance. A line from the lambda to the posterior margin of the mastoid process coincides with the lambdoidal suture, and practically overlies the parieto-occipital fissure, while a line from the lambda to a point half an inch below the fronto-malar suture indicates the parallel fissure (superior temporal sulcus).

Reid's Base-line and Trephining.—Reid's line is

drawn through the floor of the orbit and through the centre of the external auditory meatus. A great many trephine points can be found by dropping perpendiculars to this base (Fig. 24).

The following should be committed to memory,

Fig. 24.—CRANIO-CEREBRAL TOPOGRAPHY.



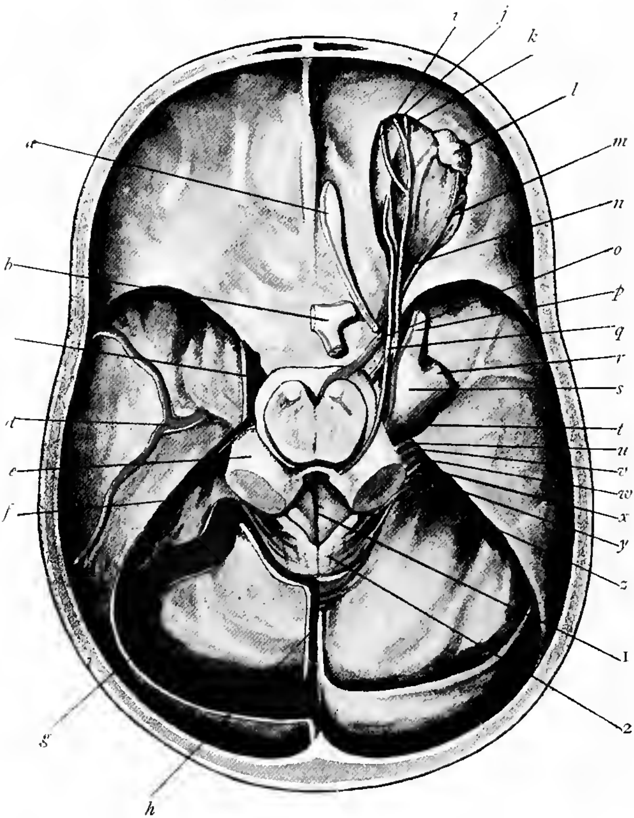
P. Pterion. A. Asterion. N. Nasion.
I. Inion. B. Bregma. S. Suprameatal fossa.
L. Lambda. G. Glabella.

1. Anterior branch of middle meningeal.
2. Lateral ventricle.
3. Temporal-sphenoidal abscess.
4. Sigmoid part of transverse sinus.
5. Horizontal part of transverse sinus.
6. Cerebellar abscess.

The dotted line in red indicates the lower portion of the cerebrum.
Reid's base line and points in blue.

and localised upon a skull or the shaven head of the cadaver:—Anterior branch of middle meningeal artery, one and a half inches behind the external angular process, and one and a half inches above the line; lateral ventricle, one and a half inches above the centre of the

Fig. 25.—Base of the Skull.



a. Olfactory bulb.
b. Optic chiasma.
c. Cavernous sinus.
d. Middle meningeal.
e. Middle peduncle.
f. Superior petrosal sinus.
g. Transverse sinus.
h. Occipital sinus.
i. Supratrocblear nerve.
j and k. Supraorbital nerve.
l. Lacrimal gland.
m. Lacrimal nerve.
n. Frontal nerve.
o. Oculo-motor nerve.
p, r, s, t. Trigeminal nerve.
q. Trochlear nerve with abducens on its inner side.
u. Facial nerve.
v. Auditory nerve.
w. Glossopharyngeal nerve.
x. Vagus nerve.
y. Accessory nerve.
z. Hypoglossal nerve.
1. Fourth ventricle.
2. Medulla.

meatus; temporo-sphenoidal abscess, three quarters of an inch above the line, along the posterior margin of the meatus; sigmoid portion of the transverse sinus, three-quarters of an inch behind the centre of the meatus on Reid's line; horizontal portion of the transverse sinus, one inch behind the centre of the meatus and a quarter of an inch above the line; cerebellar abscess, one and a half inches behind the centre of the meatus and a quarter of an inch *below* the line (Fig. 24).

Base of Skull.—It would be an impossible task in a short manual to give an elaborate account of the architecture of the base of the skull; hence a brief description of the various foramina and the main structures they transmit must suffice (Fig. 25).

Table of Foramina in Base of Skull.

Fossa.	Openings.	Structures Passing Through.
Anterior .	Foramen cæcum. Foramina of cribriform plate of ethmoid. Optic foramen.	Nasal emissary vein. Olfactory nerves, nasal nerve and ethmoidal vessels. Optic nerve and ophthalmic artery.
Middle .	Sphenoidal fissure. Foramen rotundum. Foramen ovale. Foramen spinosum. Carotid canal.	Oculo-motor, trochlear, first division of trigeminal, and abducens nerves; ophthalmic vein. Second division of trigeminal. Third division of trigeminal, and small meningeal artery. Middle meningeal artery. Internal carotid artery.

Fossa.	Openings.	Structures Passing Through.
Posterior	Internal auditory meatus.	Facial and auditory nerves; pars intermedia nerve; auditory branch of the basilar artery.
	Jugular foramen.	Glossopharyngeal, vagus, and spinal accessory nerves; commencement of internal jugular vein.
	Anterior condyloid foramen.	Hypoglossal nerve.
	Posterior condyloid foramen.	Occipital emissary vein.
	Foramen magnum.	Spinal cord and membranes; vertebral arteries; spinal portion of spinal accessory nerves.

Hypophysis Cerebri (pituitary body).—This small gland, flattened from behind forwards, occupies the pituitary fossa or sella turcica of the sphenoid, being roofed in by a process of dura mater, the diaphragma sellæ. There are two lobes—a large anterior, reddish-grey in colour, and a small white posterior. The anterior lobe (pars anterior) develops from the primitive pharynx, and consists of vascular glandular epithelium. The posterior lobe (pars nervosa) arises from the fore-brain; it is made up of neuroglia along with a few colloid-producing cells, and is covered with an epithelial investment, the pars intermedia. Connected to the posterior lobe is the infundibulum; it pierces the diaphragma sellæ to be attached to the tuber cinereum at the base of the brain. The circular blood sinus surrounds the infundibulum.

Dimensions (in average adult male)—

Vertical	. . . .	5.5 mm.
Transverse	. .	14.4 mm.
Antero-posterior	. .	21.5 mm.
Weight (at age of 30)	.	59.3 cgms. (Erdheim).

The weight gradually becomes greater until the age of forty; then it slowly decreases. A marked increase in size occurs during pregnancy. The blood supply of the gland is derived from the internal carotid, and is returned by several small veins which open into the circular sinus. The chief relations of the pituitary are the sphenoidal air sinuses below and in front, the optic chiasma anteriorly, and the cavernous sinuses laterally. For removing tumours, access to the gland is best obtained by the nasal and trans-sphenoidal route.

Recent research has shown that the hypophysis is a highly important gland, the pars anterior presiding over the growth of the skeletal tissues and the development of the sexual apparatus. An extract of the pars nervosa raises the blood-pressure, increases the secretion of urine, and stimulates the contraction of non-striped muscle.

The Fœtal Skull.—An examination of the skull of a full-time fœtus will reveal many differences from an adult cranium, the chief being—(*a*) the presence of the fontanelles; (*b*) the presence of many extra foramina for emissary veins; (*c*) the minute size of the nasal air sinuses, the antrum of Highmore, forming a small cul-de-sac immediately above the germ of the first molar tooth; (*d*) no diploë; (*e*) absence of the mastoid process (*see* Ear); (*f*) shallow glenoid fossa and no eminentia articularis, hence dislocation of the mandible is impossible; and (*g*) absence of the inion behind, and the superciliary ridges in front.

Six fontanelles are present at birth—anterior, posterior, and four lateral. They are membranous areas

situated at each of the angles of the parietal bone. The anterior is diamond-shaped, and is found at the junction of the sagittal and coronal sutures; it ossifies about the eighteenth month. The posterior, somewhat triangular in shape, is placed at the junction of the sagittal and lambdoidal sutures, and closes shortly after birth.

THE EAR.

External Auditory Meatus.—This canal extends from the concha to the membrana tympani, and has an average length of one and a quarter inches; the first half an inch is cartilaginous and the remainder osseous. The general direction is downwards, forwards, and inwards. Although so short, the canal is tortuous and undulating. Horizontally it is first convex outwards, then convex inwards, while vertically the floor is elevated about the middle of the meatus. If the pinna be drawn upwards and backwards the canal is straightened; this procedure should always be carried out in examining the external ear. The meatus is narrowest about its middle; and because of the obliquity of the tympanic membrane, the lower wall of the canal is longer than the upper.

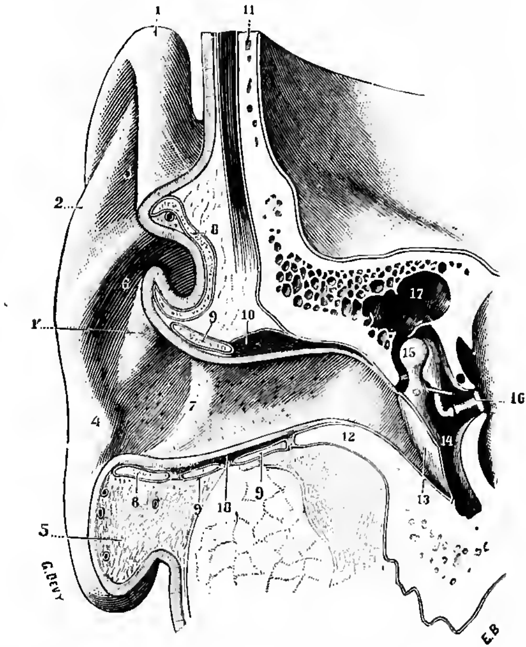
The integument of the cartilaginous portion is furnished with hair follicles, sebaceous and ceruminous glands. In connection with these glands, small abscesses, polypi, or hardened wax, sometimes form.

Relations of the Meatus.—The *superior wall* is separated by a thin plate of bone from the middle fossa of the skull, and thus suppuration in the meatus may cause meningitis.

The *anterior wall* is in relation to the parotid gland, and abscesses of the parotid often extend to the meatus. The lower jaw also lies in front of the canal, so that falls

upon the chin may fracture this wall. Copious hæmorrhage can occur from such injuries, which should not be confounded with fractures of the base of the skull.

Fig. 26.—Vertical Section of Outer and Middle Ear. (Right Ear, Posterior Segment of Section.)



1. Helix with the Root of the Helix.
1′ Crus of Helix.
2. Antihelix.
3. Scaphoid Fossa.
4. Antitragus.
5. Section through Lobule.
6. Concha.
7. Entrance to the External Auditory Meatus.
8. Section of Cartilage of Pinna.
9. Section of Cartilage of External Auditory Meatus.
10. Section of Glandular Stratum.
11. Section of Squamous portion of Temporal Bone.
12. Section of Osseous Auditory Meatus.
13. Tympanic Membrane.
14. Tympanum.
15. Ossicles.
16. Base of Stapes in Fenestra Ovalis.
17. Mastoid Antrum and Cells.

The *posterior wall* is separated by a delicate scale of bone from the mastoid cells; pus in these cells frequently discharges into the auditory meatus.

The Tympanic Membrane slopes downwards, forwards, and inwards, making an angle of about 55° with the floor of the meatus. Owing to the attachment of the handle of the malleus to the membrane, a depression is produced in the latter called the umbo. The chorda tympani nerve crosses the handle of the malleus above the equator of the membrane, and accordingly, paracentesis tympani is performed below this level. The tympanic ring into which the membrane is received, has a deficiency in its upper segment, the notch of Rivinus; this is bridged over by the pars flaccida, or membrane of Shrapnell.

On otoscopic examination, a healthy tympanic membrane is of a pearly grey colour. Antero-superiorly, a whitish spot corresponding to the processus brevis of the malleus will be detected, and radiating from it two ridges, the latter being produced by the anterior and posterior tympano-malleolar folds; they form the lateral boundaries of the pars flaccida. The handle of the malleus elevates the tympanic membrane from the whitish spot down to the umbo, and immediately behind the lower extremity of the handle, will be seen a reddish-yellow spot—the reflection of the promontory. Lastly, observe the "cone of light" which passes forwards and downwards.

Tympanum or Middle Ear.—The Eustachian tube, tympanum, and mastoid antrum are parts of an entodermal outgrowth from the first inner branchial depression.

Dimensions—

	Vertical	= 15 mm.
	Antero-posterior	= 12 mm.
Transverse	promontory to umbo	= 2 mm.
	below promontory	= 4 mm.
	above promontory	= 6 mm.

The tympanum is brought into communication with the naso-pharynx by means of the Eustachian tube, and hence the facility with which septic conditions of the pharynx or nose spread to the auditory organs. In the middle ear are found the ossicles—malleus, incus, and stapes. That area of the tympanum, which lies above the level of the membrana tympani, is termed the epitympanic recess or attic; it contains the head of the malleus and the body of the incus. In chronic otitis media, pus and carious dêbris are very apt to accumulate in the attic.

Boundaries.—Upper—the tegmen tympani, a thin plate containing a few air-cells, which supports the temporal lobe. *Lower*—an area of bone corresponding to the jugular fossa, and therefore in relation to the bulb of the internal jugular vein. *Outer*—the membrana tympani with the handle of the malleus and the chorda tympani nerve. *Inner*—in the upper part, the aquæductus Fallopii transmitting the facial nerve; immediately below this is the fenestra ovalis, containing the foot-piece of the stapes, and at a still lower level, the promontory, which is formed by the first turn of the cochlea. Posterior to the promontory is the sinus tympani, a depression in very close relation to the ampulla of the posterior semicircular canal; and immediately below the sinus is the fenestra rotunda closed by the secondary tympanic membrane. *Anterior*—The orifice of the Eustachian tube, and above this the canal for the tensor tympani muscle. *Posterior*—the aditus, passing from the attic into the mastoid antrum; the pyramid with the stapedius muscle, and the descending portion of the facial nerve in the aquæductus Fallopii.

Blood-vessels of the Tympanum.—The middle ear is supplied by branches from the internal maxillary, posterior auricular, middle meningeal, ascending pharyn-

geal, and internal carotid arteries. The veins drain into the internal jugular, external jugular, and the pterygoid plexus.

Aditus.—The aditus forms the communicating link between the attic of the tympanum and the mastoid antrum. Externally is the deep portion of the posterior wall of the osseous meatus, while internally are two eminences, a large one formed by the external semicircular canal, and a smaller one immediately in front produced by the descending part of the aquæductus Fallopii. In the radical operation for chronic otitis media, the inner wall is guarded by Stackie's protector passed from the antrum, while the surgeon breaks away the outer wall.

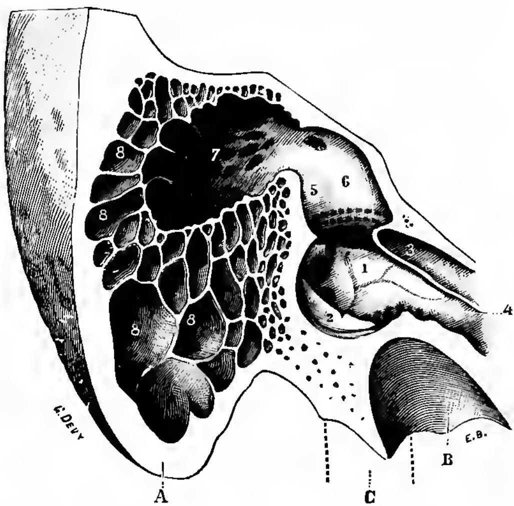
The Suprameatal Fossa is a triangular depression, whose floor forms the outer wall of the mastoid antrum. It is limited above by the suprameatal crest; below by the spine of Henle or suprameatal spine, which is the projecting edge of the posterior superior quadrant of the external auditory meatus; and behind by a tangent drawn upwards from the posterior wall of the meatus. To reach the mastoid antrum, the surgeon chisels through the floor of this fossa, and if he inadvertently trespass beyond its bounds, serious injury may result; the middle cranial fossa will be opened if the operator go above the crest, and the transverse sinus endangered if he work behind the tangent.

Mastoid Antrum.—This is a retort-shaped diverticulum from the tympanum into the mastoid process of the temporal bone. Its average dimensions in the adult are:—

Antero-posterior	12-15mm.
Transverse	7mm.
Vertical	8-10mm.
Depth from outer surface	12-14mm.

The boundaries of the antrum are of the highest surgical importance. On the *outer* side is a plate of bone derived from the squamous portion of the temporal; it forms the floor of the suprameatal fossa. The *roof* is the tegmen antri, a backward continuation of the tegmen tympani; the *floor* freely communicates with the vertical

Fig 27.—Mastoid Cavities seen on Vertical Section. (Right Mastoid, Posterior Segment of Section.)



A. Mastoid Process.
B. Glenoid fossa.
C. Internal jugular vein.
1. Inner Wall of Tympanum.
2. Membrana Tympani of which the superior part has been removed with the anterior segment of the section.
3. Canal for Tensor Tympani.
4. Osseous portion of Eustachian Tube.
5. Articular Facet for Incus.
6. Aditus.
7. Mastoid Antrum.
8. Mastoid Cells.
The position of the facial nerve is shown in red.

mastoid cells. *Behind*, is situated the descending portion of the transverse sinus, while in *front* is the prominence of the external semicircular canal, the aditus, and the tympanum. Notice that the external semicircular canal also encroaches upon the *inner* wall.

A minute channel occasionally leads from the mastoid antrum through the petrous bone to open into the floccular fossa; it is termed the petro-mastoid canal (Gruber).

The mastoid cells are of two varieties, air-containing or pneumatic, and marrow-containing or diploic. The upper group of cells are usually pneumatic, those near the apex of the mastoid process, diploic (Fig. 27).

Mastoid Region in the Child.—Development of the mastoid process is very slight until the second year. During infancy the mastoid region has the following features:—(*a*) absence of the mastoid process; (*b*) presence of the petro-squamous suture; (*c*) absence of the suprameatal crest and spine, and therefore no indications of the suprameatal fossa; (*d*) the antrum is relatively much larger than in the adult and is placed at a higher level; (*e*) no definite mastoid cells; and (*f*) the outer wall of the antrum is very thin.

Owing to the absence of the mastoid process, the facial nerve, as it leaves the stylo-mastoid foramen, is unprotected, and accordingly may be injured while making the preliminary incision to reach the antrum.

In both children and adults, remember that the floor of the antrum is on a lower level than the aditus, and therefore the former has no natural means of drainage. From middle ear and antral disease pus can spread—(*a*) backwards into the posterior cranial fossa, where the cerebellum or transverse sinus may become infected; (*b*) upwards into the middle cranial fossa, and lead to abscess of the temporal lobe; (*c*) inwards, causing labyrinthine disorders; (*d*) downwards, burrowing through the mastoid into the digastric fossa—Bezold's mastoiditis; (*e*) outwards, emerging through the external auditory meatus; or (*f*) forwards, trickling along the Eustachian tube into the naso-pharynx.

Facial Nerve.—The facial nerve issues from the lower border of the pons, and passes into the internal auditory meatus lying superficial to the pars intermedia and the auditory nerves ; at the bottom of the meatus it enters the aquæductus Fallopii. In this canal the nerve is first directed outwards between the cochlea and the vestibule, then backwards along the inner wall of the tympanum, and finally arches over the fenestra ovalis to proceed downwards on the posterior wall of the tympanum, immediately in front of the external semicircular canal (*see* Aditus). Emerging through the stylo-mastoid foramen the facial enters the parotid gland, where it lies on a level with the lower border of the tragus, and splits into two divisions—temporo-facial and cervico-facial.

Of the branches given off in the Fallopian aqueduct only two need be mentioned, the nerve to the stapedius muscle and the chorda tympani ; the latter leaves the cranium at the canal of Huguier at the bottom of the Glaserian fissure and joins the lingual nerve. Between the stylo-mastoid foramen and the parotid gland, two branches arise, the posterior auricular and a muscular twig to the stylo-hyoid and the posterior belly of the digastric. The temporo-facial divides into temporal, malar, and infra-orbital branches ; and the cervico-facial into buccal, supramandibular, and inframandibular. Each of these communicates with the nearest branch of the trigeminal.

Surgically, the facial nerve may be injured in basal fractures, and is often damaged by chronic otitis media.

THE ORBITAL REGION.

Boundaries of the Orbit.—The *roof* is formed by the orbital plate of the frontal into which the frontal air-sinus extends for a variable distance, and the lesser wing of the sphenoid. This plate is very fragile, and may be easily penetrated by instruments thrust into the orbit; in the majority of cases such a wound would injure the under surface of the brain.

The *floor* is formed by the orbital plate of the superior maxilla, the malar, and part of the palate bone. Notice that this surface forms the roof of the antrum of Highmore, and growths from that sinus may thus bulge into the orbit, and cause proptosis.

The *inner wall* is formed by the following bones:—the nasal process of the superior maxilla, lacrimal, os planum of the ethmoid, and the sphenoid. The inner wall of the orbit corresponds to the outer wall of the nose, and therefore tumours may extend from one cavity to the other. *Externally*, are the frontal, malar, and sphenoid.

The chief *contents* of the orbit are (*a*) the eyeball, with the capsule of Tenon; (*b*) the lacrimal gland; (*c*) the ophthalmic vessels; (*d*) the ocular muscles and the levator palpebræ superioris; and (*e*) the optic, oculomotor, trochlear, ophthalmic division of the trigeminal, and abducens nerves.

Fascia Bulbi (Capsule of Tenon).—This membrane separates the eyeball from the orbital fat, and provides a socket for the former to move in. The capsule is a forward continuation of the dural sheath of the optic nerve; it covers the sclerotic and passes beneath the ocular conjunctiva, with which it blends near the corneo-sclerotic junction. Between the sclerotic and the capsule is a space crossed by fine trabeculæ—

Tenon's space; it is continuous behind with the sub-arachnoid and sub-dural spaces. The inferior portion of the fascia bulbi is called the suspensory ligament of Lockwood. It stretches across from the malar bone to the lacrimal bone, supporting the eyeball like a hammock. During the removal of the superior maxilla for malignant disease, the surgeon endeavours to preserve the attachments of the suspensory ligament, for if they be interfered with, the eyeball is apt to prolapse upon the cheek.

The fascia bulbi is perforated by the vessels and nerves entering the eyeball, and by the ocular muscles. Each muscle receives a tubular sheath from the capsule, and the sheaths of the internal and external recti give off fibrous processes to the lacrimal and malar bones. The processes are termed the internal and external check ligaments; they are intimately connected with the attachments of the suspensory ligament.

THE EYEBALL.

The eyeball rests in the anterior portion of the orbital fossa, slightly nearer the roof than the floor, and about 2 mm. nearer the external than the internal wall. It consists of three coverings or tunics, within which are three refractive media. The average dimensions are:—

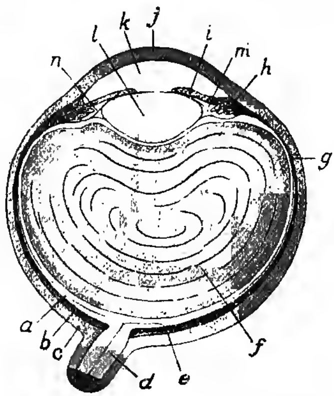
Antero-posterior	=	24 mm.
Vertical . .	=	23.2 mm.
Transverse .	=	23.6 mm.

The coverings are—(*a*) an external or protective tunic—the sclerotic and cornea; (*b*) a middle or vascular layer—the uveal tract; and (*c*) an inner or nervous lamina—the retina. The refractive media are the aqueous humour, the lens, and the vitreous humour. (Fig. 28.)

Outer Coat.—On examining this layer, notice that

the sclerotic represents the posterior four-fifths; it is white and opaque, and slightly overlaps the periphery of the cornea—the transparent anterior portion. From before backwards three strata can be distinguished in the cornea (*a*) epithelium; (*b*) a tough fibrous zone—the tunica propria; and (*c*) the thin elastic membrane of Descemet. The epithelium is a forward continuation of the conjunctiva bulbi, which forms an external invest-

Fig. 28.—Antero-Posterior Section of Eyeball (Diagrammatic).



a, Retina; *b*, choroid; *c*, sclerotic; *d*, optic nerve; *e*, macula lutea; *f*, vitreous humour; *g*, termination of retina anteriorly—ora serrata; *h*, ciliary enlargement; *i*, iris; *j*, cornea; *k*, anterior chamber of the eye; *l*, lens; *m*, posterior chamber of the eye; *n*, suspensory ligament.

ment of the anterior part of the sclerotic. Owing to the large number of twigs received from the trigeminal nerve, the cornea is highly sensitive. Blood vessels are, however, practically absent, so that its nutrition depends upon the vessels of the conjunctiva.

Middle Coat.—The uveal tract comprises the choroid, the ciliary body, and the iris; the two former are in intimate relation to the inner surface of the sclerotic, while the iris is a circular diaphragm having

a central orifice, the pupil. Except at the corneo-sclerotic junction, and at the site of entrance of the optic nerve, the choroid is only loosely connected to the sclerotic. The choroid is extremely vascular, its capillaries blending to form four or five veins, the venæ vorticosæ, which are tributaries of the ophthalmic. A large quantity of black pigment, melanin, occupies the choroidal epithelial cells.

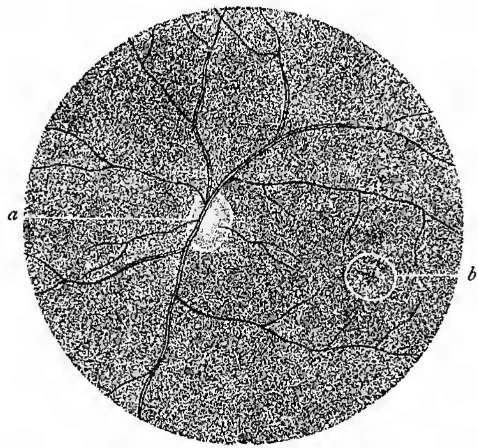
The Ciliary Body.—This mainly consists of the ciliary muscle surrounded by a mass of connective tissue. The anterior surface (pars plicata) presents a series of vascular tufts, the ciliary processes. The posterior surface (pars plana) is smooth. Projecting from the middle of the base of the ciliary body is the deeply pigmented iris. The sphincter iridis is a bundle of unstriped muscle surrounding the pupil, and lying external to the sphincter will be found a layer of cells, the dilator iridis. Three nerves supply the uveal tract, the trigeminal being sensory, the oculomotor going to the ciliary muscle and the sphincter iridis, and the cervical sympathetic to the dilator iridis.

Inner Coat.—A little dissection will separate the retina into two strata—(*a*) a pigmented lamina blending with the choroid, and (*b*) a nervous membrane, formed by the radiation of the optic nerve, which rests against the hyaloid chamber. The nerve lamina, as it passes forwards, stops short of the ciliary body, ending in a tooth-like border, the ora serrata.

Two things must be specially noted in the retina—(*a*) the yellow spot or macula lutea, situated at the posterior pole; it has a central depression, the fovea centralis; (*b*) the optic disc or blind spot, found about 3 mm. to the nasal side of the macula. The optic disc consists of nerve fibres only.

Blood Vessels of the Retina (see Fig. 29).—The arteria retinæ centralis (a branch of the ophthalmic) enters the eyeball in the sheath of the optic nerve. In the fœtus the vessel extends, as far as the lens, and passes through the vitreous. Previous to birth, however, the portion beyond the retina disappears, its remnant forming the hyaloid canal. Emerging through the optic disc the arteria retinæ centralis divides into

Fig. 29.—Fundus of Eye as seen by Indirect Method.



a, Optic disc. *b*. Yellow spot.

superior and inferior; each of these subdivides into temporal and nasal. From the primary stems branches are given off to the yellow spot, superior and inferior macular. The macula also receives twigs from the temporal branches, but the fovea centralis is bloodless.

The retinal lymphatics are continuous with those of the optic nerve, and therefore with the subarachnoid space of the brain.

The Crystalline Lens and the Vitreous.—The vitreous humour somewhat resembles the Whartonian jelly of the umbilical cord, and is limited by a delicate membrane, the hyaloid membrane. On its anterior surface will be found a fossa into which the posterior part of the lens fits. The crystalline lens is biconvex, projecting more behind than in front, and enclosed in a capsule which is strengthened anteriorly by the suspensory ligament. A lymphatic space, the canal of Petit, surrounds the lens.

The Anterior and Posterior Chambers.—Both of these spaces contain diluted lymph, the aqueous humour. The excess of fluid from the anterior chamber is drained away by a small venous sinus termed the canal of Schlemm. It traverses the corneo-sclerotic junction, and opens into the anterior ciliary veins. The boundaries of the chambers are:—

Anterior Chamber.—In front is the cornea; behind are the iris, and the lens opposite the pupil.

Posterior Chamber.—Laterally, the ciliary body; in front, the iris; and behind, the anterior surface of the lens.

Muscles of the Eyeball.—The nerve supply and actions of the ocular muscles are given in the accompanying table:—

Table of Muscles of the Eyeball.

Muscle	Nerve Supply	Action
External rectus .	Abducens (6th) .	Abducts eyeball
Internal rectus .	Oculo-motor (3rd)	Adducts eyeball
Superior rectus .	Oculo-motor .	Pulls eyeball up and in
Superior oblique.	Trochlear (4th) .	Pulls eyeball down and out
Inferior rectus .	Oculo-motor .	Pulls eyeball down and in
Inferior oblique .	Oculo-motor .	Pulls eyeball up and out

Direct elevation of the eyeball is brought about by the combined action of the superior rectus and the inferior oblique, while direct depression is produced by the inferior rectus and the superior oblique working together.

Oculo-motor Nerve—This nerve issues from the brain on the inner side of the crura cerebri immediately in front of the pons. It pierces the dura-mater in the vicinity of the posterior clinoid process, traverses the outer wall of the cavernous sinus (page 114), and reaches the orbit by passing through the sphenoidal fissure.

After emerging from the outer side of the crura cerebri, the *trochlear* nerve penetrates the dura-mater at a point just external to the oculo-motor. It proceeds forwards in the outer wall of the cavernous sinus to enter the orbit through the sphenoidal fissure.

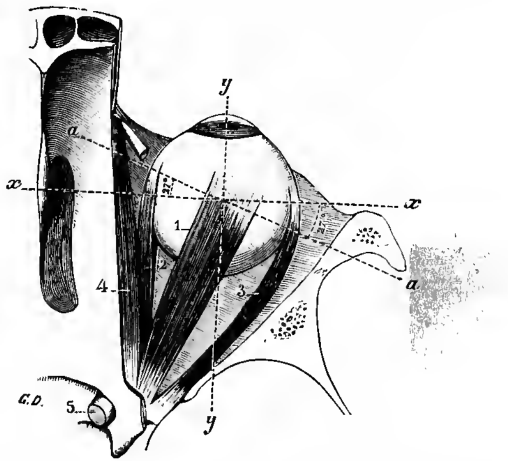
The *abducens* has its superficial origin at the lower border of the pons, near the middle line. After piercing the dura-mater close to the dorsum sellæ, the nerve accompanies the internal carotid artery along the inner wall of the cavernous sinus, and goes through the sphenoidal fissure into the orbit.

Ophthalmic Vessels.—Arising from the internal carotid opposite the anterior clinoid process, the ophthalmic artery enters the orbit, along with the second cranial nerve, by passing through the optic foramen. In the orbit it first lies external to the optic nerve, then crosses it superficially to reach the inner side, and lastly, bends forwards to terminate by dividing into frontal and nasal. Its other branches are, ciliary to the eyeball: arteria retinæ centralis, supraorbital, lacrimal, muscular, meningeal, palpebral, and ethmoidal. The orbital veins practically correspond with the branches of the artery. They unite to form two main trunks, the superior and the inferior ophthalmic

veins, which reach the cavernous sinus through the sphenoidal fissure. Pressure upon the sinus, or thrombosis of its contents, will therefore result in protrusion of the eyeball.

Lacrimal Apparatus.—This apparatus consists of the lacrimal gland and its ducts, from which the tears

Fig. 30.—The Orbit, seen from Above, to Show the Mode of Action of the Four Recti Muscles. (From Testut.)



1. Rectus Superior.
2. Rectus Internus.
3. Rectus Externus.
4. Superior Oblique, with Tendon passing round the Trochlea.
5. Optic Nerve.

y y, Antero-posterior axis of Eyeball.
x x, Transverse Axis of Eyeball.
a a, Axis of Rotation of Superior and Inferior Recti forming an Angle about 27° with transverse axis *x x*.

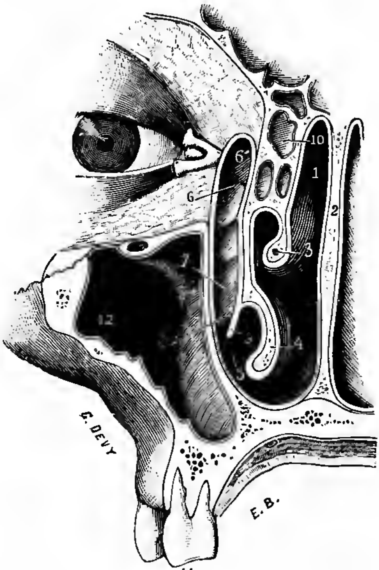
flow to the surface of the eyeball, and also of certain channels along which the tears are conveyed to the nose.

The gland is deeply placed in the upper part of the outer canthus, and consists of two lobes—orbital and palpebral. It is fixed by fibrous bands to the orbital periosteum. Two nerves supply the gland—the sympathetic, and the lacrimal branch of the ophthalmic

division of the trigeminal; its vascular supply is derived from the lacrimal branch of the ophthalmic artery.

The lacrimal ducts extend from the gland to the upper eyelid near the superior conjunctival fornix.

Fig. 31.—Section Opening Lacrimal Sac and Nasal Duct (Viewed from the Front). (From Testut.)



1. Right Nasal Fossa.
2. Septum.
3. Middle Turbinated Bone.
4. Lower Turbinated Bone.
5. Inferior Meatus.
6. Lacrimal Sac.
7. Nasal Duct.
8. Opening into Nose.
9. Valve of Hasner.
10. Ethmoidal Cells.
11. Second Premolar.
12. Antrum of Highmore.

The punctum lacrimale opens in each lid on a papilla close to the inner canthus, and from the puncta, the canaliculi extend to the lacrimal sac. Of the two canaliculi, the inferior is the larger; it first dips downwards, then passes upwards and inwards; while

the superior canaliculus ascends, then runs inwards and slightly downwards. The canals terminate in the outer and interior part of the lacrimal sac, just below its middle.

Normally, each punctum is in contact with the eyeball, and any cause which removes the punctum from the globe—as in ectropion—interferes with the passage of tears to the sac, and compels them to flow on to the cheek (epiphora).

The lacrimal sac lies in a groove on the nasal process of the superior maxilla and lacrimal bones. It receives the canaliculi, and terminates below in the nasal duct. Crossing in front of the sac is the tendon of the orbicularis palpebrarum—the internal tarsal ligament or tendo oculi.

The nasal duct is half an inch long, and opens into the inferior meatus of the nose, immediately below and behind the anterior extremity of the inferior turbinate bone. Three bones form the osseous canal lodging the duct, namely, the lacrimal, superior maxilla, and inferior turbinate. Its direction is downwards, backwards, and outwards—a course which should be borne in mind when passing a probe along the duct. The aperture is frequently guarded by a fold of mucous membrane, the valve of Hasner. The surface anatomy of the duct is represented by a line drawn from the inner canthus to the interval between the first molar and second premolar teeth.

The Eyelids.—In each eyelid the following layers are met with from before backwards:—(*a*) the skin; (*b*) subcutaneous tissue (devoid of fat); (*c*) orbicularis palpebrarum; (*d*) a layer of condensed fibrous tissue (the tarsal plate); (*e*) Meibomian glands; and (*f*) conjunctiva. In the upper eyelid the levator palpebræ superioris is found, and also a thin sheet of unstriped

muscle (Müller's palpebral muscle). In cases of exophthalmic goitre this muscle contracts and produces a slight retraction of the upper eyelid, known as Stellwag's sign. The orbicularis palpebrarum derives its motor supply from the facial nerve; the levator palpebræ superioris from the oculo-motor; and Müller's muscle from the cervical sympathetic. When the levator palpebræ superioris is paralysed, ptosis results. Two main sets of arteries ramify in the eyelids, namely, the superior and inferior palpebral branches from the ophthalmic and lacrimal arteries.

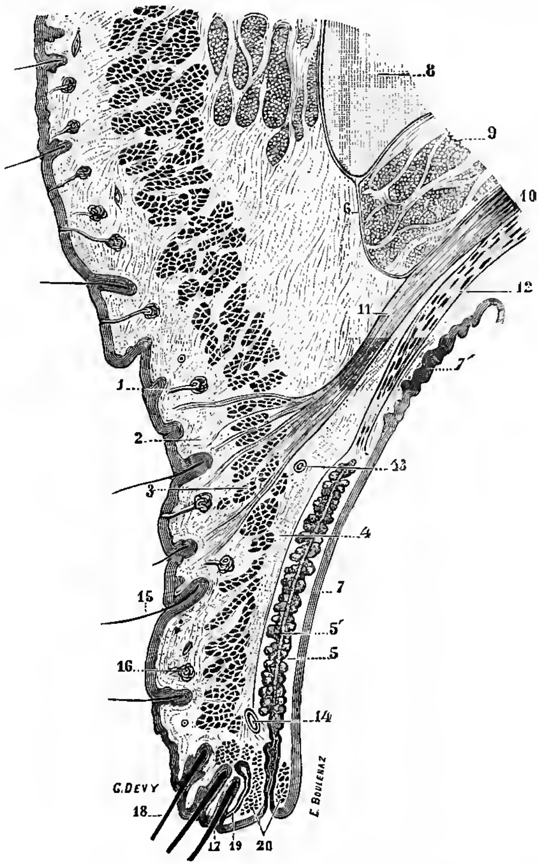
The subcutaneous tissue is very lax and readily becomes œdematous. Extravasated blood travels rapidly in it, as in a "black eye."

The tarsal plates are attached to the margins of the orbit by the palpebral and tarsal ligaments, which thus prevent the extension of extravasated blood from the orbit to the subcutaneous tissue—as in fracture of the base of the skull involving the roof of the orbit—the blood then passes beneath the conjunctiva, and forms an important diagnostic symptom. A subconjunctival ecchymosis always preserves its scarlet colour, owing to the thinness of the conjunctiva permitting oxygenation of the underlying blood.

The Meibomian glands may be seen by everting the lids. Due to the occlusion of the duct the contents are occasionally retained, forming *tarsal cysts.* Close to the margin of the eyelid are the openings of the glands of Moll; they are modified sebaceous glands and are in relation to follicles of the eyelashes. Suppuration occurring in one of these glands is known as a stye.

The *conjunctiva* is prolonged from the eyelid (conjunctiva palpebrarum) to the surface of the eyeball (conjunctival bulbi) forming a cul-de-sac—conjunctival fornix—beneath each eyelid. The conjunctiva palpe-

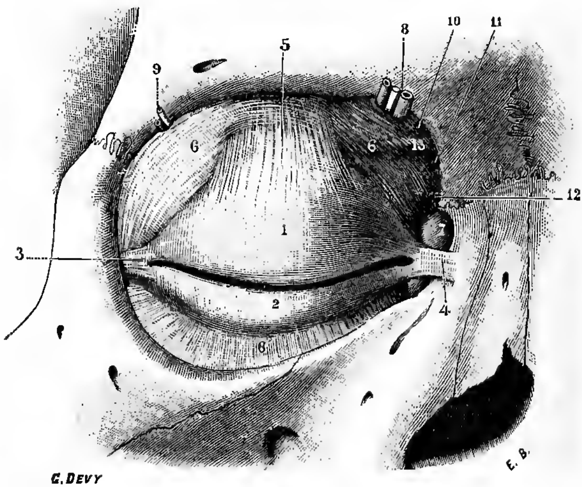
Fig. 32.—SAGITTAL SECTION OF UPPER EYELID. (After TESTUT.)



1. Skin.
2. Subcutaneous Tissue.
3. Orbicularis Palpebrarum.
4. Sub-muscular areolar Tissue.
5. Tarsal Plate with
5'. Meibomian Glands.
6. Septum Orbitale.
7. Palpebral Conjunctiva with
7'. Fornix.
8. Superior Orbital Margin.
9. Fatty Tissue of Orbit.
10. Levator Palpebræ Superioris Muscle, with 11. its Tendon, and 12. its muscular part.
13. and 14. Artery.
15. Hairs.
16. Sudoriparous Glands.
17. Free edge of Lid, with 18. Cilia.
19. Gland of MOLL.
20. Muscle of RIOLAN and opening of Meibomian Glands.

brarum is closely adherent to the lids, but the conjunctiva bulbi is only loosely attached to the sclerotic, except at the corneo-sclerotic junction. Internally, as the conjunctiva passes from the upper to the lower eyelid, it gives rise to a crescentic fold, the *plica semilunaris.* Between the inner extremities of the eyelids is a small

Fig. 15.—Right Eye—Tarsi and their Ligaments.
(From Testut.)



1. Tarsus Superior.
2. Tarsus Inferior.
3. External Tarsal Ligament.
4. Internal Tarsal Ligament.
5. Tendon of Levator Palpebræ Superioris.
6 and 6′. Septum Orbitale.
7. Lacrimal Sac.
8. Supra-orbital Vessels and Nerves.
9. Branches of Lacrimal Artery and Nerve.
10. Aperture giving Passage to Supratrochlear Nerve.
11. Aperture for Nasal Nerve.
12. Aperture for Angular Vein.
13. Tendon of Superior Oblique.

bay, the *lacus lacrimalis*; it lodges a reddish mass covered with fine hairs—the *caruncle.*

THE NASAL FOSSÆ.

Each nasal fossa presents for examination an outer wall, a roof, a floor, and two orifices—the anterior and

posterior nares; the fossæ are separated from each other by the nasal septum.

The *roof* is formed mainly by the nasal bones, the body of the sphenoid, and the cribriform plate of the ethmoid. The latter is extremely fragile and easily perforated by an instrument driven upwards through the nose; such an accident would injure the inferior surface of the cerebrum.

The *floor* comprises the palatal processes of the superior maxillæ, and the horizontal plates of the palate bones. It is smooth and almost transverse—a fact which should be remembered when passing a Eustachian catheter.

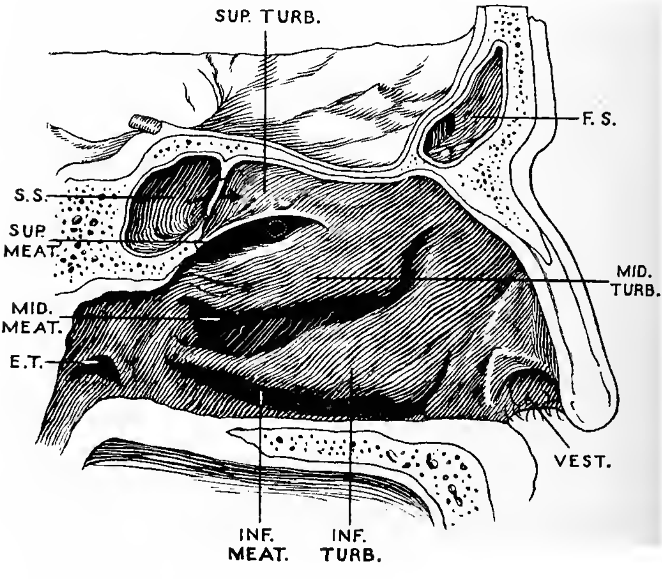
The *nasal septum* is usually deflected more or less to one side, and is chiefly formed by the vertical plate of the ethmoid, the vomer, and the triangular fibro-cartilage. Anteriorly the septum supports the nasal bones, and accordingly, when the septum undergoes necrosis, as sometimes occurs in syphilis, the nasal bones tend to drop and produce flattening of the bridge of the nose. The septal branch of the superior coronary artery (a branch of the facial) lies about half an inch above the anterior nares. Rupture of this vessel is a common source of arterial epistaxis.

The *posterior nares* or choanæ are on a slightly lower level than the anterior nares, and hence pus and blood tend to gravitate backwards into the pharynx. In size they are one inch vertically and half an inch transversely. Each is bounded as follows:—Externally is the internal pterygoid plate, internally the vomer, above the sphenoid and the ala of the vomer, while below is the horizontal plate of the palate.

The *outer* wall is the most complicated portion of the nasal fossa. The bones entering into it are the lacrimal, the lateral mass of the ethmoid carrying the superior

and middle turbinate processes, the superior maxilla, the vertical plate of the palate, the internal pterygoid plate, and the inferior turbinate. This portion of the nose may be divided into three areas—(*a*) the vestibule, (*b*) the atrium and the olfactory sulcus, and (*c*) the region of the meatuses. The vestibule is the part into which the

Fig. 34.—Outer Wall of the Left Nasal Fossa.



F.S. Frontal Sinus. S.S. Sphenoidal Sinus. E.T. Eustachian Tube.

anterior nares open ; it is lined with skin bearlng stiff hairs called vibrissæ. A prominent fold, the limen nasi, marks the junction of the vestibule and the atrium. The atrium is a wide depression leading to the middle meatus, and is separated from the olfactory sulcus by an almost vertical ridge, the agger nasi.

The Region of the Meatuses.—(*a*) *Inferior*—intervenes between the floor of the nose and the inferior turbinate. It is almost horizontal in direction. The nasal duct opens into the anterior part of the space. (Page 135).

(*b*) *Middle*—is between the inferior and middle turbinates. Under cover of the middle turbinate, a rounded eminence, the bulla ethmoidalis can be seen; the middle ethmoidal cells open on its upper aspect. The cleft between the bulla and the uncinate process of the ethmoid is called the hiatus semilunaris. Through it the middle meatus communicates with a narrow groove, the infundibulum. The latter runs obliquely upwards and forwards, parallel with the uncinate process. The anterior ethmoidal cells open into the forepart of the groove, while the aperture of the antrum of Highmore, the ostium maxillare, is situated in the hinder portion.

In old age a second opening from this sinus, the ostium secundum, is frequently present. Notice that in many cases the infundibulum is prolonged upwards to the frontal sinus as the naso-frontal duct.

(*c*) *Superior*—is situated between the superior and middle turbinate bones. The posterior ethmoidal cells open into this meatus.

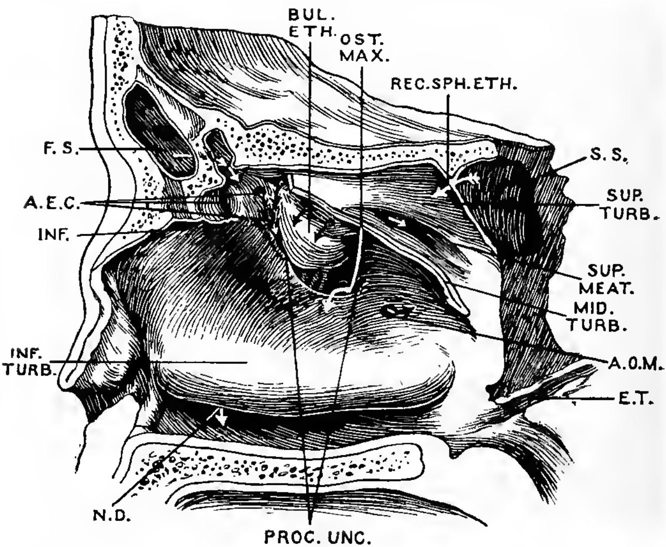
(*d*) *Spheno-ethmoidal recess*—a small area usually present above the superior meatus. The aperture of the sphenoidal cells will be found in it.

The olfactory area of the nasal fossa comprises the superior turbinate bone, and the upper third of the nasal septum.

Nasal Mucous Membrane.—It has been previously mentioned that the vestibule is covered by skin; the remainder of the nose is furnished with a highly vascular and sensitive membrane, the Schneiderian membrane.

This lining is adherent to the periosteum over which it lies, and is continuous with the conjunctiva along the lacrimal passages, with the membrane of the accessory nasal air sinuses through their respective ostia, and with that of the naso-pharynx through the posterior

Fig. 35.—Outer Wall of the Right Nasal Fossa, after Removal of the Middle Turbinate.



F.S.	Frontal Sinus.	A.O M.	Accessory Ostium Maxillare.
A.E.C.	Anterior Ethmoidal Cells.	E.T.	Eustachian Tube.
INF.	Infundibulum.	N.D.	Nasal Duct.
S.S.	Sphenoidal Sinus.	PROC. UNC.	Processus Uncinatus.

nares. On the septum and the turbinate bones the membrane contains many venous channels; they are exceedingly numerous over the inferior turbinate, and in this situation the Schneiderian membrane resembles erectile tissue.

Nerves and Blood Vessels of the Nose.—From twelve to twenty olfactory nerves supply the upper part of the outer wall and the septum; they are the special nerves concerned in smelling. The nerves of common sensation are derived from the ophthalmic and the superior maxillary divisions of the trigeminal, and from Meckel's ganglion. The two chief arteries supplying the nose are the naso-palatine and the descending or posterior palatine, branches of the internal maxillary.

ACCESSORY NASAL AIR-SINUSES.

The accessory sinuses are the (*a*) frontal; (*b*) sphenoidal; (*c*) ethmoidal; and (*d*) antrum of Highmore.

Frontal.—Although these sinuses begin to develop at birth, they cannot be recognised as definite cavities until a much later period. The average dimensions are:—

Antero-posterior	=	1 inch.
Transverse .	=	1 inch.
Vertical . .	=	1¼ inches (Logan Turner).

They are somewhat triangular in shape, with the bases in front and the apices behind, and correspond approximately to the inner portions of the superciliary ridges. The floor is the thinnest wall, and accordingly pus tends to point at the upper and inner angle of the orbit. The sinuses are rarely symmetrical, the left sinus being usually smaller than the right, and occasionally one or other may be absent; they are separated by a vertical bony septum which is seldom mesial in position. On the lowest part of the floor, near the septum, is an aperture, the ostium frontale, from which passes the naso-frontal duct. When the duct does not terminate in the infundibulum, it opens

directly into the upper and anterior part of the middle meatus.

Sphenoidal.—The sphenoidal air sinuses at birth are the size of a small pea (Onodi). They are usually of unequal size, and are separated by a perpendicular bony septum.

Each opens by an aperture situated on the anterior wall—the sphenoidal ostium, which, as previously stated, communicates with the spheno-ethmoidal recess. The average dimensions are—

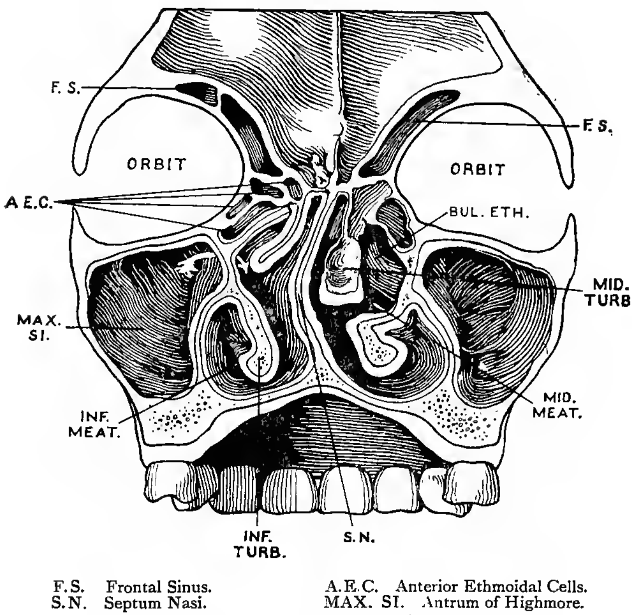
Antero-posterior . = $\frac{7}{8}$ inch.
Transverse . . = $\frac{3}{4}$ inch.
Vertical . . = $\frac{7}{8}$ inch (Logan Turner).

An examination of a skull will show that the sinuses are related above to the optic chiasma, the pituitary body, and frequently the pons Varolii; laterally, are the cavernous sinuses and internal carotid arteries. At the junction of the roof with the outer wall two structures are found, namely, the optic nerve and the ophthalmic artery. Below each sinus is the Vidian canal, transmitting the Vidian vessels and nerve.

Ethmoidal Cells.—The ethmoidal cells occupy the lateral mass of the ethmoid bone. They are bounded externally by a considerable portion of the inner wall of the orbit, namely, by the os planum of the ethmoid, the lacrimal, and the nasal process of the superior maxilla. Remember that the nasal duct forms an important external relation. Behind is the sphenoidal concha. On the inner side the cells are limited by the superior and middle turbinate bones and the ethmoidal bulla. Above, is the inner segment of the orbital plate of the frontal, while below, the cells are closed in by the inner part of the orbital plate of the superior maxilla. The relation of the ostia of the ethmoidal cells to the nasal cavities has been previously referred to.

Antrum of Highmore.—This is a pyramidal cavity situated in the body of the superior maxilla. It commences to develop during fœtal life (page 125), and grows until the age of thirty. The lowest part is in the interspace between the 1st and 2nd molar teeth

Fig. 36.—Coronal Section through the Anterior Part of the Nose.



F.S. Frontal Sinus. A.E.C. Anterior Ethmoidal Cells.
S.N. Septum Nasi. MAX. SI. Antrum of Highmore.
The arrow is directed through the ostium maxillare.

(Macalister). Although of variable size, the following represent the average dimensions :—

Antero-posterior	=	$1\frac{1}{4}$ inches.
Transverse .	=	1 inch.
Vertical . .	=	$1\frac{1}{2}$ inches (Logan Turner)

The aperture of communication with the nose has already been described.

The apex is formed by the malar; and the base, or nasal surface, by the superior maxilla, inferior turbinate, vertical portion of palate, lateral mass of ethmoid, and occasionally the lacrimal. Above is the orbital plate of the superior maxilla, with the infra-orbital vessels and nerve. The lower boundary is formed by the alveolar process of the superior maxilla. In front will be found the facial surface of the superior maxilla, while behind are the zygomatic surface of the superior maxilla, and the spheno-maxillary fossa containing the internal maxillary artery and Meckel's ganglion.

Into the floor of the antrum the roots of one or two molar teeth project, and in connection with these suppuration sometimes occurs, resulting in an empyema of the antrum.

The orifice of communication between the nose and the cavity is very small and situated at a high level, so that in empyema of this sinus a considerable amount of pus may collect. To drain the cavity an opening may be made (*a*) through the outer wall of the nose, just below the inferior turbinate bone; (*b*) through the canine fossa; or (*c*) through the alveolus of the first molar tooth.

BONES OF THE FACE.

Nasal Bones.—The bridge of the nose is formed by the nasal bones, and when fractured the fragments are usually driven inwards. The under surface of the bones is supported by the vertical portion of the ethmoid. Such a close relation of the nasal bones to the ethmoid explains the extension of injury to the base of the brain, which sometimes occurs in fracture of this region.

Malar.—Owing to its great strength the malar is rarely fractured ; but from the shell-like structure of the superior maxilla which supports it, the upper jaw may be broken by blows on the malar.

The Maxilla.—The outline of the facial surface of the bone should be carefully made out. Examine the bone *in situ* on the skull, and notice the surfaces and connections. These are of immense surgical importance, as tumours of the upper jaw usually modify the shape of all the surfaces of the bone. Thus the facial surface bulges forwards, and the cheek becomes prominent. The tumour may push upwards the orbital surface and displace the eyeball. If it grow inwards, the cavity of the nose is encroached upon ; and a growth downwards will project into the roof of the mouth and alter the shape of the palate. The posterior surface of the maxilla is directed towards the zygomatic fossa, and here comes into close relation with the pterygoid plates of the sphenoid; and thus, malignant growths which develop in this region of the bone soon involve the body of the sphenoid and the base of the skull.

The Mandible.—This bone consists of three main parts—body, angle, and ramus ; the latter terminates above in two processes—the coronoid and the condyle. Separating the condyle from the coronoid process is the sigmoid notch ; it transmits the masseteric vessels and nerve. The inferior dental and lingual nerves can be reached by enlarging the sigmoid notch in a downward direction. On the inner aspect of the ramus is a foramen for the inferior dental vessels and nerve. The lingula, or spine of Spix, lies immediately in front of this foramen, and attached to the spine is the internal lateral ligament. The mental foramen, with the mental vessels and nerve (branches of the inferior dental), is

found on the outer surface of the body, midway between the premolar teeth.

The inner surface of the jaw is separated from the oral cavity merely by the mucous membrane; and as the latter is readily torn, fractures of this bone are usually compound.

The weakest part of the bone is in the region of the alveolus of the canine tooth, and accordingly this is the commonest site for fracture to occur. When such an injury takes place, the anterior fragment is pulled downwards by the muscles which extend to the hyoid bone, while the posterior fragment is tilted slightly upwards by the masseter, temporal, and internal pterygoid. During the removal of the inferior maxilla, remember that the internal maxillary vessels and the auriculo-temporal nerve lie behind the neck of the condyle. To avoid injuring these structures, rotate the bone well outwards before disarticulating.

PTERYGO-MAXILLARY REGION.

In order to expose this region it is necessary, in the first place, to divide the zygoma, and draw it downwards along with the masseter muscle; then snip off the coronoid process and turn it upwards together with the temporal muscle. When this dissection has been carried out, a fatty mass is encountered, under which will be found the internal and external pterygoid muscles, the internal maxillary artery, and the branches of the inferior division of the trigeminal nerve.

Internal Maxillary Artery.—This vessel is one of the terminal branches of the external carotid, being given off in the parotid gland. It enters the pterygo-maxillary region between the neck of the mandible and the internal lateral ligament, where it comes into relation

with the external pterygoid. At first it lies below this muscle, resting on the internal pterygoid, and crossing over the inferior dental and lingual nerves. Next it runs superficial to the external pterygoid (but sometimes under cover of it), and lastly, passes between the two heads of this muscle to reach the spheno-maxillary fossa by way of the pterygo-maxillary fissure.

Numerous branches arise from the internal maxillary, the chief being the inferior dental, middle meningeal, posterior palatine, infra-orbital, Vidian, and naso-palatine.

Temporo-Mandibular Articulation.—The condyle of the lower jaw is separated from the anterior part of the glenoid fossa by the interarticular fibro-cartilage, which thus materially diminishes the depth of that cavity, and renders the position of the bone less secure. In front of the glenoid fossa is the eminentia articularis, on which the fibro-cartilage glides, and if the mouth be opened very widely the condyle is apt to slip over this eminence into the zygomatic fossa, carrying with it the fibro-cartilage, as this is attached partly to the condyle. The external pterygoid muscle, which is inserted into the front of the condyle of the jaw, is also fixed partly to the meniscus.

The capsule of the joint is thickest externally (external lateral ligament), the fibres here passing downwards and backwards from the tubercle of the zygoma to the neck of the condyle. When the mandible is depressed these fibres are made tense, and tend to prevent dislocation. The internal lateral ligament is thin and at some distance from the joint; it stretches from the spine of the sphenoid to the spine of Spix. Behind, the condyle is in close relation to the external auditory meatus and the tympanum; they are sometimes injured by blows on the chin.

Two distinct varieties of movement occur at the

temporo-mandibular joint, a ginglymus or hinge action between the condyle and the fibro-cartilage, and an arthrodial or gliding movement between the fibro-cartilage and the temporal bone. The muscles acting upon the joint are :—

Depressors—Platysma, mylo-hyoid, anterior belly of digastric and genio-hyoid muscles.

Elevators—Masseter, internal pterygoid, and anterior fibres of temporal.

Protractor—Chiefly the external pterygoid.

Retractor—Posterior fibres of temporal.

Lateral movements are produced by the external pterygoids acting alternately.

THE TRIGEMINAL NERVE.

Shortly after issuing from the side of the pons Varolii, the trigeminal nerve has the Gasserian (semi-lunar) ganglion developed on its sensory element. The ganglion lies in the middle cranial fossa near the apex of the petrous portion of the temporal bone. In some cases, where the roof of the carotid canal is deficient, part of the ganglion overlaps the internal carotid artery, a point of considerable importance. A pouch of dura mater, the cavum Meckelii, surrounds the ganglion, the latter being closely adherent to the roof of the pouch. The chief relations are: the cavernous sinus lying to the inner side, the internal carotid, which is first inferior, then internal; and two nerves beneath, namely, the motor root of the trigeminal and the great superficial petrosal. Three trunks arise from the anterior surface of the ganglion; the ophthalmic and superior maxillary divisions are entirely sensory; the inferior maxillary division is a mixed nerve, being joined by the motor root as it passes through the foramen ovale.

The ophthalmic division leaves the cranium by way of the sphenoidal fissure, and gives off three branches—frontal, nasal, and lacrimal, the former subdividing into supra-orbital and supra-trochlear. The superior maxillary division reaches the spheno-maxillary fossa *via* the foramen rotundum; it then goes through the spheno-maxillary fissure into the orbit, where it runs beneath the orbital periosteum, and transverses the infra-orbital canal to terminate on the face. Meckel's ganglion is situated in the spheno-maxillary fossa, and communicates with the superior maxillary division by means of the two spheno-palatine nerves. On the outer side of the ganglion is the internal maxillary artery. Branches from Meckel's ganglion are distributed to the orbit, palate, nose, and pharynx. In addition to the spheno-palatine nerves, the superior maxillary furnishes twigs to the orbit, and dental branches to the teeth of the upper jaw. The total length of the second division of the fifth nerve is two inches.

The inferior maxillary nerve passes through the foramen ovale to enter the pterygo-maxillary region. It first gives off two branches, a small recurrent twig through the foramen spinosum to the dura mater, and the nerve to the internal pterygoid and otic ganglion. Then the main trunk bifurcates into an anterior and a posterior division; the former supplies the masseter, temporal, and external pterygoid muscles, terminating as a sensory nerve, the long buccal. From the posterior division three nerves arise—the auriculo-temporal, the lingual, and the inferior dental.

Emerging from beneath the external pterygoid, the inferior dental descends on the internal pterygoid to the interval between the ramus of the jaw and the internal lateral ligament. It is accompanied by the artery of the same name, and has the lingual nerve

anterior and internal. Before reaching the inferior dental canal it gives off the mylo-hyoid branch to supply the mylo-hyoid and the anterior belly of the digastric. In the canal the inferior dental bifurcates into the incisor and the mental nerves. The lingual nerve also lies at first under cover of the external pterygoid where it is joined by the chorda tympani. It next descends between the internal pterygoid and the ramus of the jaw, crosses beneath the mucous membrane of the mouth to the space between the mylo-hyoid and hyoglossus muscles, passes beneath Wharton's duct, and lastly, along the under surface of the tongue.

The nerve is occasionally divided with the view of relieving the pain caused by an epithelioma of the tongue. To perform the operation make an incision through the mucous membrane half an inch below and behind the wisdom tooth.

At the present day trigeminal neuralgia is often treated by injecting a mixture of alcohol and β-eucaine into the main nerve trunks. A special syringe is used possessing a blunt needle. To reach the ophthalmic division, introduce the needle at a point immediately to the inner side of the fronto-malar suture ; the sphenoidal fissure is encountered at a depth of from $3\frac{1}{2}$ to 4 c.m.s. To inject the superior maxillary trunk is a more difficult procedure. A line is prolonged downwards from the posterior edge of the orbital process of the malar on to the zygoma. Introduce the needle on the lower edge of the zygoma $\frac{1}{2}$ c.m. behind this line ; the instrument passes through the pterygo-maxillary fissure into the spheno-maxillary fossa, striking the nerve at a depth of 5 c.m.s. The inferior maxillary is reached by placing the needle along the lower border of the zygoma $2\frac{1}{2}$ c.m.s. in front of the descending root. The distance from the surface is 4 c.m.s.

BLOOD-VESSELS AND NERVES ON THE FACE.

Facial Artery (*external maxillary*).—A branch of the external carotid, the facial artery, after passing beneath the stylo-hyoid and the posterior belly of the digastric muscles, occupies a groove on the deep surface of the sub-maxillary gland. The vessel appears on the face, by going over the jaw at the anterior inferior angle of the masseter; it lies immediately beneath the platysma, and is crossed superficially by the supra-mandibular branch of the facial nerve; here the artery may be compressed against the jaw, and the condition of the pulse examined by the anæsthetist during an operation. The vessel passes in a tortuous manner towards the angle of the mouth and side of the nose, and terminates near the inner canthus by anastomosing with the frontal branch of the ophthalmic artery. The following branches are given off on the face:—inferior labial, inferior and superior coronaries, lateralis nasi and angular.

The *facial* (*external maxillary*) *vein* lies posterior and in close contact with the artery as it crosses the lower jaw, but it takes a straight course from the inner canthus. It receives an important tributary, the deep facial, which partly drains the pterygoid plexus. This in turn communicates with the cavernous sinus (see Emissary Veins). The facial vein ends by joining the anterior division of the temporo-maxillary to form the common facial, which opens into the internal jugular.

Superficial Temporal Artery.—This vessel arises from the bifurcation of the external carotid in the parotid gland opposite the neck of the mandible, and ascends over the zygoma, immediately in front of the tragus, to the temporal region. At a point one and a

half inches above the zygoma it divides into anterior and posterior branches. The anterior branch reaches the forehead and front of the scalp, while the posterior branch extends towards the occiput and vertex of the head. As hæmorrhage from either of these branches is usually very free, it should be remembered that the main trunk can be controlled by pressure against the zygoma.

The superficial temporal vein and the auriculo-temporal nerve lie posterior to the artery.

Crossing the masseter, just above Stensen's duct from the parotid gland, is a branch of the superficial temporal called the transverse facial.

Nerves.—The nerves found on the face are branches of the facial (see p. 133) and trigeminal, the former supplying the muscles of expression, and the latter the muscles of mastication and the integument of the face.

The surgeon frequently resects a portion of a branch of the trigeminal in cases of severe neuralgia. It is therefore necessary to be thoroughly familiar with the surface anatomy of these nerves. The points are given in the following table :—

Nerve.	Origin.	Situation where found.
Supra-orbital .	Ophthalmic division .	Junction of the inner and middle thirds of the superior orbital margin.
Supra-trochlear .	Ophthalmic division .	Midway between the supra orbital and the middle line of the fore-head.

Nerve.	Origin.	Situation where found.
Nasal . . .	Ophthalmic division .	Between the nasal bone and lateral cartilage.
Infra-orbital .	Superior maxillary division	$\frac{1}{4}$ inch below the middle of the inferior orbital margin.
Mental . .	Inferior maxillary division	Project a line downwards through the supra-orbital and infra-orbital nerves ; it will pass through the mental.
Inferior dental .	Inferior maxillary division	Midway between the angle of the jaw and the root of the coronoid process.
Lingual . .	Inferior maxillary division	$\frac{1}{2}$ inch below and behind the wisdom tooth.
Auriculo-temporal	Inferior maxillary division	Immediately in front of the tragus.

THE SALIVARY GLANDS.

The Parotid.—This gland occupies the interval between the lower jaw and the mastoid process, and spreads for a variable distance over the masseter muscle. It is encapsulated by a prolongation of the deep cervical fascia, the envelope being strongest on the superficial aspect of the gland. It sends off several processes (i) on the face (socia parotidis), (ii) into the posterior part of the glenoid fossa (glenoid lobe), and (iii) behind the styloid process. In front of the

styloid, the gland projects inwards towards the internal carotid artery, resting upon the outer pharyngeal wall. This explains why pus, instead of reaching the surface of the parotid, may burrow inwards towards the pharynx, and also why a retro-pharyngeal abscess sometimes bursts into the parotid region.

The boundaries are—*above*, the posterior two-thirds of the zygoma; *below*, the stylo-maxillary ligament; *behind*, the external auditory meatus, mastoid process, and sterno-mastoid muscle; in *front* there is no definite limit. The deep relations of the parotid are the masseter; the styloid process with the muscles attached; the internal jugular vein and the internal carotid artery; the glossopharyngeal, vagus, spinal accessory and hypoglossal nerves.

Several important structures traverse the gland. Most superficial of all notice two nerves—the great auricular and the facial with its branches. Next in order come a group of veins—the superficial temporal, joining with the internal maxillary to form the temporo-maxillary, and the posterior auricular uniting with the posterior branch of the temporo-maxillary to form the external jugular.

On a deeper plane than the veins are the external carotid artery, giving off the posterior auricular, the superficial temporal, and the internal maxillary; the auriculo-temporal nerve is also found.

In addition to lymphatic glands embedded in its substance (see page 211), a definite group, the preauricular, is found superficially. They lie immediately in front of the tragus, and drain the anterior portion of the pinna and meatus, the temporal region of the scalp, and the external part of the eyelids. In children suffering from pediculi, irritation of the scalp often leads to enlargement of these glands.

Stensen's duct arises from the anterior portion of the gland. It crosses the masseter, having the transverse facial artery along its upper border and the buccal branches of the facial nerve along its lower border, pierces the buccinator, and opens into the vestibule of the mouth opposite the upper second molar tooth. It is two and a half inches long and one eighth of an inch in diameter. "The calibre of the duct is very much greater than that of its orifice, and for this reason the duct may, to some extent, be looked upon as a reservoir for the saliva, as well as a duct for its conveyance" (Birmingham).

To mark out Stensen's duct, take a line from the lobule of the ear to a point midway between the anterior nares and the red margin of the upper lip. The middle third of this line represents the duct.

The **Submaxillary Gland** lies immediately below the jaw in the anterior part of the digastric triangle. It rests upon the mylo-hyoid muscle, and gives off a deep process round the posterior border of the muscle. The chief relations are: the lower jaw above, the anterior belly of the digastric in front, and the stylo-maxillary ligament, which separates it from the parotid, behind. Superficial to the gland are found the skin, fasciæ, platysma, and facial vein; the facial artery passes forward in a groove on the deep aspect of the sub-maxillary. The gland is enclosed in a pocket formed by the superficial layer of the deep cervical fascia.

Wharton's duct issues from the deep process, and runs forwards upon the hyoglossus between two nerves—the lingual above and the hyoglossal below. It then passes over the genio-hyoglossus, being crossed superficially by the lingual nerve, and lastly, goes beneath the sublingual gland to open on the summit of a small

papilla near the frenum linguæ. The total length of the duct is about one and a half inches.

The **Sublingual Gland** is found beneath the mucous membrane of the floor of the mouth. It is the smallest of the salivary glands. Above is a fold of mucous membrane, the plica sublingualis; internally, the geniohyoglossus; externally, the lower jaw; and below, the mylohyoid, Wharton's duct, and the lingual nerve.

The gland discharges its secretion by means of numerous minute tubes, the ducts of Rivinus; although some of these open directly into the floor of the mouth, the majority terminate in Wharton's duct.

THE MOUTH AND PHARYNX.

Lips.—The greater part of each lip is formed by connective tissue and the orbicularis oris. The outer surface of the muscle is covered by skin and fascia; its inner surface by a mucous membrane containing numerous mucous glands. Between the muscle and the mucous membrane the coronary artery lies; it is quite close to the free margin of the lip. This may bleed very profusely in operations on the lip.

Hare lip is due to a failure of union of the maxillary and the mesial nasal (globular) processes. The deformity may be complete or incomplete, single or double. It is frequently associated with an undue prominence of the premaxilla, and may coexist with a cleft palate.

The Palate.—The *hard palate* is formed by the palatal processes of the superior maxilla and palate bones. It is covered by mucous membrane, which is very dense and inseparably united to the periosteum of the bones.

The soft palate or velum is attached to the posterior edge of the hard palate, and consists of connective

tissue, muscles, blood-vessels, nerves, and glands. The muscles entering it comprise the levator and tensor palati, palato-glossus, palato-pharyngeus, and azygos uvulæ. From behind forwards the following strata are encountered:—(*a*) pharyngeal mucous membrane; (*b*) posterior layer of palato-pharyngeus; (*c*) azygos uvulæ; (*d*) levator palati; (*e*) anterior layer of palato-pharyngeus; (*f*) tensor palati; (*g*) palato-glossus; and (*h*) oral mucous membrane.

With the exception of the tensor palati, supplied by the trigeminal, all the muscles of the soft palate derive their nerves from the pharyngeal plexus.

On an average the thickness of the soft palate in adults is a quarter of an inch.

The hamular process of the sphenoid is a very important landmark, and can be paloated through the soft palate. It lies half an inch behind the upper wisdom tooth. The tensor palati hooks round this process.

The blood supply of the palate is mainly derived from the descending palatine, a branch of the internal maxillary artery. It emerges from the posterior palatine foramen, which is situated a quarter of an inch in front of the hamular process. After giving off a few branches to the velum, it continues forwards in the muco-periosteum a short distance from the junction of the hard palate with the alveolar process. On reaching the anterior palatine foramen it anastomoses with the naso-palatine artery.

In operations for cleft palate the descending palatine must be avoided and preserved; therefore each lateral incision is made external to the artery. Troublesome hæmorrhage may also arise from the artery after excision of the superior maxilla.

Cleft palate is due to the non-union of the deep parts

of the mesial, nasal, and maxillary processes. It may range in severity from a bifid uvula to a complete gap extending from the naso-pharynx into the nostril. Three types are described—bipartite, tripartite, and median, the former being the most prevalent (Haug.) In the bipartite variety the premaxillary element undergoes normal union on one side, more commonly the right, with the maxillary process. The cleft is generally between the central and lateral incisors, but sometimes traverses the interval between the lateral incisor and the canine teeth.

In connection with the soft palate three folds can be seen: (*a*) the uvula hanging from the middle of the posterior border of the velum; (*b*) the anterior pillars of the fauces stretching to the margins of the tongue, and containing the palato-glossus muscles; (*c*) the posterior pillars of the fauces extending to the pharynx, which are formed by the palato-pharyngeus muscles.

Teeth.—Twenty milk or deciduous teeth are found; they are represented by a dental formula of:—

Incisors $\frac{2}{2}$ canine $\frac{1}{1}$ molars $\frac{2}{2}$

The first milk teeth to appear are the lower central incisors; they erupt during the seventh month. Delay is often associated with rickets.

There are thirty-two permanent teeth, and their formula is:—

Incisors $\frac{2}{2}$ canine $\frac{1}{1}$ premolars $\frac{2}{2}$ molars $\frac{3}{3}$.

During the sixth year the first molars erupt. They are the earliest permanent teeth to appear.

In general outline each tooth consists of three parts: (*a*) that protruding beyond the gum—the *crown*, (*b*) that covered by the gum—the *neck*, and (*c*) that embedded in the alveolus or socket—the *root*. The blood vessels and nerves supplying the teeth enter at the apex of the root. Remember that the roots of the upper incisors and

canines, and the lower premolars are conical; those of the lower incisors and canines, and the upper premolars are flattened laterally.

The upper molars have three roots, while the lower molars have only two.

Surrounding the alveolus and the roots of the teeth is a vascular layer of tough connective tissue, the alveolar periosteum; it is continuous with the gum.

In young adults tumours arising from dental germs sometimes form. These odontomata may be either solid or cystic, and often contain imperfect teeth.

They are generally associated with the permanent molars.

Tongue.—The tongue is a muscular organ, the muscular fibres being separated by a certain amount of vascular areolar tissue. It consists of two distinct portions, the anterior two-thirds being termed the buccal part, and the posterior third the pharyngeal part; the line of separation is indicated on the dorsum by the sulcus terminalis.

Examine the dorsum and note the foramen cæcum. It is the remains of an entodermal structure, the thyreoglossal tract, which grew downwards through the substance of the hyoid bone to form the thyreoid body. Plum-coloured cysts may arise in connection with the duct or its orifice. These swellings are exceedingly vascular, and often contain colloid material resembling that of the thyreoid body.

From the foramen cæcum two furrows extend, one, the raphé, stretches forwards to the tip of the tongue; the other is Λ-shaped, and is termed the sulcus terminalis. Its two limbs diverge forwards and outwards to the lingual margins.

On the dorsum of the tongue, the mucous membrane in front of the sulcus terminalis presents numerous papillæ,

of which the most prominent are the vallate. They are eight to twelve in number, and run parallel with the sulcus. The mucous membrane of the pharyngeal portion has no papillæ, but it is studded with lymphoid nodules (the lingual tonsils); each possesses a minute central orifice into which mucous glands pour their secretion.

Slightly in front of the attachments of the anterior pillars of the fauces to the margin of the tongue, notice a few linear ridges, the vestigeal remnants of the papillæ foliatæ.

Elevate the tip of the tongue and examine the under surface. The mucous membrane is smooth, and mesially forms the frenum linguæ. In some cases this fold is abnormally short, causing the tongue to be depressed, and fixed to the floor of the mouth so that it cannot be freely protruded. This condition, known as *tongue-tie*, is relieved by division of the frenum. In performing the operation it is important to remember the position of the ranine vessels, which lie a short distance external to the frenum. For this reason the point of the scissors should be directed *downwards* and *backwards* towards the floor of the mouth, and the mucous membrane torn rather than divided. On each side of the frenum is a delicate fringed ridge, the plica fimbriata. The ranine vein lies between the frenum and the plica fimbriata; the artery is external to the vein, but hidden from view. Beneath the mucous membrane, near the apex of the tongue, are the glands of Nühn (anterior lingual). A dilatation of one of the ducts of these glands constitutes one variety of ranula.

Connections of Tongue—

(i) To the hyoid bone by the { hyoglossus.
genio-hyoglossus.
inferior lingualis.
septum linguæ.

(ii.) To the lower jaw by the {genio-hyoglossus. / mucous membrane.

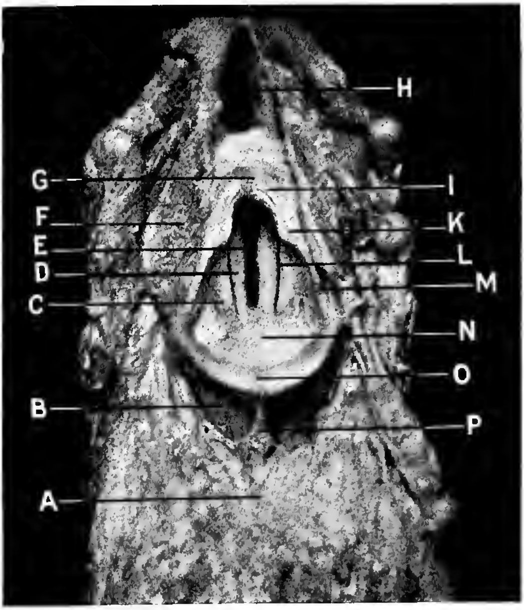
(iii.) To the styloid process by the stylo-glossus.

(iv.) To the soft palate by the palato-glossus.

(v.) To the epiglottis by the glosso-epiglottic fold.

(vi.) To the pharynx by the two pharyngo-epiglottic folds.

Fig. 37.—Dorsum of Tongue and Larynx from above.



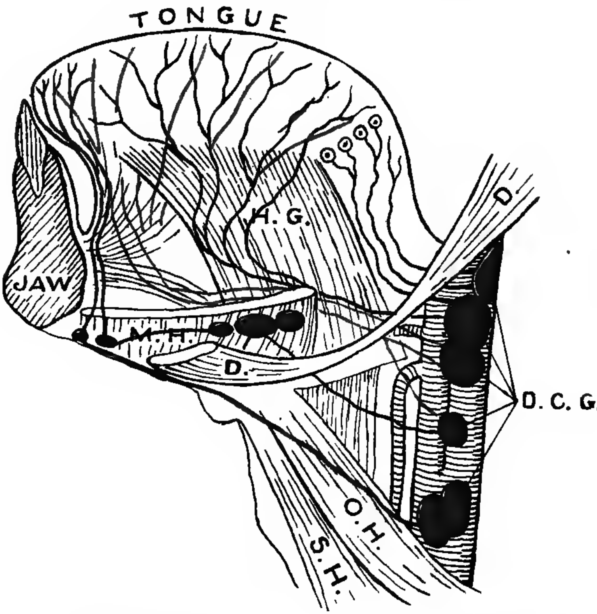
A. Dorsum of Tongue.
B. Vallecula.
C. False Vocal Cord.
D. True Vocal Cord.
E. Rima Glottidis.
F. Sinus Piriformis.
G. Inter-arytænoid Fold.
H. Œsophagus.

I. Arytænoid cartilage.
K. Cartilage of Wrisberg.
L. Opening of Ventricle of Larynx.
M. Arytæno-epiglottic Fold.
N. Cushion of Epiglottis.
O. Epiglottis.
P. Glosso-epiglottic Fold.

Nerves of the Tongue.—The motor nerve of the tongue is the hypoglossal. The mucous membrane of

the anterior two-thirds is supplied by the lingual and chorda tympani nerves, the latter being the nerve connected with the sense of taste; while the posterior third is innervated by the glosso-pharyngeal and the superior laryngeal branch of the pneumogastric.

Fig. 38.—Lymphatics of the Tongue.

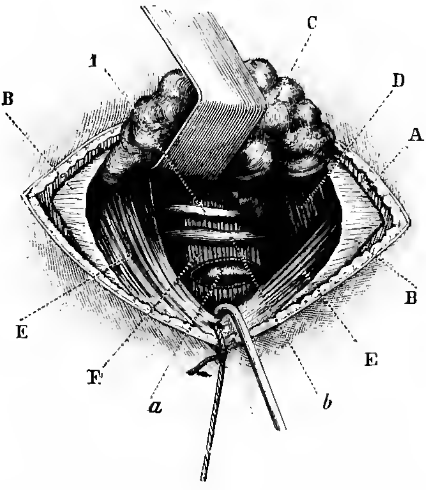


DCG. Deep. cervical glnnds.
D. Diagrastic.
HG. Hyo-glossus.
MH. Mylo-hyoid.
OH. Omo-hyoid.
SH. Sterno-hyoid.

Lymphatics of the Tongue.—The majority of the lymphatics of the tongue are found in the sub-mucous layer, while the remainder ramify in the muscular part of the organ; both sets freely communicate. There are four main drainage areas, (a) *anterior* (apical) pass

to the sub-mental glands, and to a gland of the deep cervical chain situated on the upper border of the anterior belly of the omo-hyoid; (b) *posterior* (basal), run below the tonsil, and then accompany the tonsillitic vessels to the upper group of the deep cervical chain; (c) *lateral*, go to the sub-maxillary glands and the upper group of the deep cervical chain near the bifurcation of

Fig. 39.—Ligature of the Right Lingual Artery. (After Treves.)



A, Platysma; B, Cervical fascia; C, Submaxillary gland; D, Mylo-hyoid; E, Digastric; F, Hyoglossus; *a*, Lingual artery; *b*, Ranine vein; 1, Hypoglossal nerve.

the common carotid artery; (d) *central*, terminate in a similar manner to the lateral set.

Lingual Vessels.—The lingual artery arises from the external carotid opposite the great cornu of the hyoid bone, and is divided into three parts by the hyoglossus muscle.

At first the artery passes obliquely upwards, then

curves downwards and forwards, the loop thus formed being crossed superficially by the hypoglossal nerve. It next runs beneath the posterior belly of the digastric and the stylo-hyoid to reach the hyoglossus. Under shelter of this muscle the artery then passes forwards, parallel with the upper border of the hyoid bone; and lastly, it emerges from beneath the anterior border of the hyoglossus to ascend on the genio-hyoglossus as far as the apex of the tongue. The terminal portion of the vessel—*i.e.*, the part beyond the hyoglossus, is called the ranine artery, and is covered merely by the mucous membrane of the mouth.

The first part, and the beginning of the second part of the artery, rest upon the middle constrictor of the pharynx, the remainder upon the genio-hyoglossus.

Three veins are associated with the lingual artery, two venæ comites, and the ranine; the latter runs over the hyoglossus, immediately below the hypoglossal nerve. All the lingual veins open into the internal jugular.

The branches of the lingual are—suprahyoid, dorsalis linguæ, sublingual, and ranine. The dorsalis linguæ extends upwards beneath the posterior border of the hyoglossus to supply the dorsum of the tongue, the front of the epiglottis, and the tonsil.

In the substance of the tongue only two anastomoses take place between the lingual arteries: (*a*) the ranines communicate at the tip of the tongue; and (*b*) the dorsales linguæ inosculate around the foramen cæcum.

Either the first or the second part of the artery can be ligated by an incision in the neck.

The former operation is very difficult, because (*a*) the artery is crossed by a plexus of veins formed by the linguals, common facial, and superior thyreoid; and also by the hypoglossal nerve; (*b*) the space between the

external carotid and the hyoglossus is very limited; and (*c*) the artery is lying upon the mobile lateral wall of the pharynx. When the artery is tied in its second part, the dorsalis linguæ is not cut off, and so may be the source of copious hæmorrhage.

The Pharynx.—The pharynx extends from the base of the skull to the lower border of the cricoid cartilage; there it becomes continuous with the œsophagus.

It is five inches long, with the transverse diameter greater than the antero-posterior; the widest part is opposite the hyoid bone, and the narrowest at the œsophageal orifice. Foreign bodies are most usually impacted at the latter spot, and owing to the immediate proximity of the glottis, are very liable to produce dyspnœa or even asphyxia.

The *roof* of the pharynx is formed by the basilar process of the occipital and the body of the sphenoid; and since this is the most common site of naso-pharyngeal growths, it is important to notice that it can be investigated by the finger passed upwards from the mouth, behind the soft palate.

The *posterior wall* is covered with a fibrous layer, the bucco-pharyngeal fascia, continuous laterally with the carotid sheath, and is in relation to the anterior surfaces of the upper five cervical vertebræ (which can be palpated through the mouth), the prevertebral muscles, and the prevertebral layer of cervical fascia. Separating the bucco-pharyngeal and prevertebral fasciæ is a collection of loose areolar tissue in which suppuration sometimes occurs, forming a retro-pharyngeal abscess.

Anteriorly, the pharynx is bounded by the nose, the mouth, and the larynx; it communicates with these cavities by the posterior nares, the isthmus of the fauces, and the glottis, respectively.

The *lateral walls* are in relation to the styloid process and its muscles; the carotid sheath and its contents; the glosso-pharyngeal and hypoglossal nerves, and the ascending pharyngeal artery.

Three parts of the pharynx are described:—

(*a*) *Naso-pharynx*, from the basis cranii to the soft palate. Its cavity remains patent under all conditions. In addition to the posterior nares the orifices of the Eustachian tubes are found. They indicate the position of the first internal branchial depression. Each tube is bounded above and behind by a salient ridge, the Eustachian cushion, and from the back part of the cushion a fold of mucous membrane, the salpingo-pharyngeal fold, passes to the lateral pharyngeal wall. Were it not for the Eustachian cushion, the introduction of a Eustachian catheter would be an operation of considerable difficulty. In passing such a catheter, care must be taken not to mistake the lateral recess of the pharynx (fossa of Rosenmüller) for the Eustachian orifice. The recess is a slit on the side wall of the pharynx immediately behind the Eustachian cushion; it represents the upper portion of the second internal branchial depression.

The mucous membrane around and between the Eustachian orifices is rich in lymphoid tissue. In the child it forms a prominent mass, the pharyngeal tonsil. Hypertrophy of this mass gives rise to the condition known as adenoids, which results in deafness, mouth breathing, and imperfect chest development.

The *pharyngeal hypophysis* is the pharyngeal end of the buccal evagination which budded upwards to form the pars anterior of the pituitary body (hypophysis cerebri). It lies beneath the mucous membrane of the pharyngeal roof. Its size varies with the age, as it slowly enlarges until forty years. In adults it is 5 mm.

vertically and ½-1 mm. wide. "The pharyngeal hypophysis is to be regarded as an actively functionating gland, rather than a rudimentary or involuting one" (Kanavel).

(*b*) *Oral pharynx*, extends from the soft palate to the tip of the epiglottis. Between the free edge of the soft palate and the posterior pharyngeal wall is the pharyngeal isthmus; it is occluded during deglutition by the contraction of the two palato-pharyngeus muscles.

Three folds of mucous membrane will be observed passing forwards from the epiglottis; the central one terminates on the pharyngeal portion of the tongue, the glosso-epiglottic fold, while the lateral ones, the pharyngo-epiglottic folds, reach the side walls of the pharynx. The depressions enclosed by these ridges are termed the valleculæ (Fig. 37).

(*c*) *Laryngo-pharynx.*—The anterior wall of this portion of the pharynx comprises the epiglottis; the glottis, leading into the larynx, and flanking it on each side, the piriform fossa; and the posterior surfaces of the cricoid and arytænoid cartilages.

The piriform fossa is the remains of the fourth inner branchial depression. Foreign bodies sometimes lodge in it.

Structure of the pharynx.—Three definite strata can be recognised: (*a*) a muscular coat, mainly formed by the three constrictors; (*b*) an intermediate layer—the pharyngeal aponeurosis; and (*c*) a mucous membrane. External to the pharynx is a thin layer of fibrous tissue called the bucco-pharyngeal fascia. The constrictor muscles overlap each other from below upwards. They are all inserted into a median raphé on the posterior wall of the pharynx, and are innervated by the pharyngeal plexus (branches from the pneumogastric, glosso-

pharyngeal, and sympathetic). The interval between the superior constrictor and the base of the skull is termed the sinus of Morgagni—the Eustachian tube, and the tensor and levator palati muscles pass through it. Between the upper part of the pharynx and the prevertebral muscles are two or three important lymph glands. They are very large in children, and often suppurate, forming one variety of retro-pharyngeal abscess.

Blood vessels of the pharynx.—The following arteries furnish branches to the pharynx—ascending pharyngeal, ascending palatine and tonsillitic from the facial (external maxillary), dorsalis linguæ, and the pterygo-palatine branch of the internal maxillary. The pharynx is drained by the pharyngeal venous plexus which lies outside the muscular coat. It partly opens into the pterygoid plexus, and partly into the internal jugular vein.

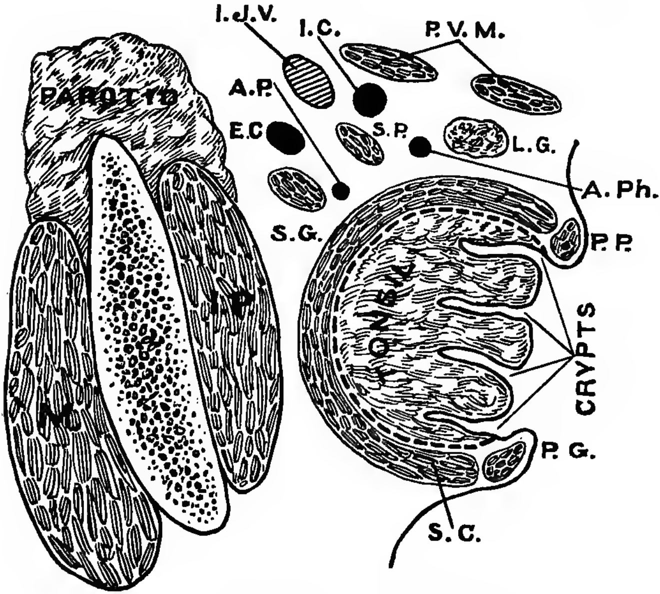
Eustachian tube.—This stretches from the anterior wall of the tympanum to the side of the naso-pharynx, where it opens opposite the posterior extremity of the inferior turbinate bone. It is directed downwards, forwards, and inwards, and is one and a half inches long. The orifice is somewhat triangular, and is found about half an inch above the soft palate, half an inch below the pharyngeal roof, half an inch behind the posterior extremity of the inferior turbinate, and half an inch anterior to the posterior pharyngeal wall.

In children the tube is shorter, wider, and more horizontal than in adults, and hence the frequency with which otitis media follows pharyngeal sepsis.

The upper third of the tube is osseous, while the lower two-thirds are cartilaginous; at the junction of the two parts is a constriction, the isthmus.

During deglutition the tensor and levator palati muscles, especially the former, open the tube, and thus allow the atmospheric pressure on each side of the membrana tympani to be equalised.

Fig. 40.—THE TONSIL AND ITS RELATIONS (Diagrammatic).



A.P. Ascending Palatine Artery.
A.P.L. Ascending Pharyngeal Artery.
E.C. External Carotid.
I.C. Internal Carotid.
I.J.V. Internal Jugular Vein.
I.P. Internal Pterygoid.
L.G. Lymphatic Gland.
M. Masseter.
P.G. Palato-glossus.
P.P. Palato-pharyngeus.
P.V.M. Prevertebral Muscles.
S.C. Superior Constrictor.
S.G. Stylo-glossus.
S.P. Stylo-pharyngeus.

To pass a Eustachian catheter, the instrument is carried along the floor of the inferior meatus with the point directed downwards, until it reaches the posterior wall of the naso-pharynx. It is then rotated

inwards through a quarter of a circle, and drawn forwards until the beak touches the edge of the nasal septum. If now the catheter be pushed slightly backwards, and rotated downwards and outwards through half a circle, the point will enter the orifice of the tube.

Tonsils.—The palatine or faucial tonsils are two oval masses of lymphoid tissue occupying the greater part of the interval between the pillars of the fauces. Each lies opposite the angle of the mandible.

The external surface possesses a distinct capsule derived from the pharyngeal aponeurosis; it separates the tonsil from the superior constrictor muscle. Above is the small supratonsillar fossa, the remains of the lower part of the second inner branchial depression. It is usually closed on its internal aspect by a ridge of mucous membrane, the plica triangularis.

In addition to its capsule and the superior constrictor muscle, the tonsil has extremely important relations on its outer side. They are the internal pterygoid and stylo-glossus muscles; the facial (external maxillary), ascending palatine, ascending pharyngeal, and internal carotid arteries; the internal jugular vein (see Fig. 40). Remember that the tonsil rests on a plane three-quarters of an inch anterior to the internal carotid, so that if ordinary care be exercised during tonsillectomy, there need be no fear of wounding this vessel. The artery in closest proximity to the tonsil is the facial.

In structure the tonsil consists of nodules of lymphoid tissue covered by mucous membrane, the latter lining the crypts or depressions present on the inner surface. The crypts are sometimes filled with retained secretion, epithelial débris, or even calcareous concretions.

Five arteries supply the tonsil—dorsalis linguæ; ascending pharyngeal; ascending palatine and tonsillitic branches of the facial; and the descending palatine. They chiefly enter at the lower pole. The nerves are derived from the pharyngeal plexus and the glosso-pharyngeal.

The lymphatics drain into the superior group of the deep cervical chain, from a point just behind the angle of the mandible to the hyoid bone.

MIDDLE LINE OF THE NECK.

The hyoid bone can be felt immediately under the chin; between it and the symphysis menti is the median raphé of the mylo-hyoid muscles. Below the hyoid bone identify the thyreoid cartilage; it is more prominent in the male (pomum Adami) than in the female, and very indistinct in children. The hyoid bone is linked to the thyreoid cartilage by the thyreo-hyoid membrane. Below the thyreoid cartilage palpate the cricoid, and between the two the crico-thyreoid membrane, the latter being crossed by the small crico-thyreoid artery. From the cricoid cartilage to the supra-sternal notch, the trachea can be recognised, its upper part being superficial. The second, third, and fourth rings are masked by the isthmus of the thyreoid body. Flanking the middle line of the neck notice the anterior jugular veins; they are usually connected by one or more transverse anastomosing branches.

Thyreotomy.—The thyreoid cartilage is quite superficial, and its alæ may be separated by a mesial incision without dividing any important structures. Difficulty will be encountered when the cartilage is ossified.

Laryngotomy.—This operation is practically always performed at the present day as a preliminary to ex-

tensive operations on the mouth, face, and jaws. By packing the upper part of the tube, septic discharges are prevented from reaching the lower respiratory passages, while the anæsthetic can be administered through the lower part of the opening.

In laryngotomy, an incision is made through the crico-thyreoid membrane. It is a simple procedure, as the membrane is almost subcutaneous. Some trouble may arise from division of the crico-thyreoid branch of the superior thyreoid artery, which lies at this level, but as the membrane is divided transversely, the artery usually escapes. When cutting the membrane, be careful to keep the knife from projecting upwards, or the vocal cords may be injured.

Tracheotomy—(high and low).—In this procedure the trachea is opened *above* or *below* the isthmus of the thyreoid body. The trachea is practically subcutaneous above the isthmus, being merely covered by skin, superficial and deep fascia, and overlapped by the sterno-hyoid muscles; but below the isthmus the trachea recedes from the surface, and has in front of it the sterno-hyoid and sterno-thyreoid muscles, the inferior thyreoid veins, and occasionally the thyreoidea ima artery; in children, the thymus gland forms an additional relation.

In performing tracheotomy it is highly important to work in the anatomical middle line, else the carotid sheath and its contents will be endangered; therefore distinguish carefully between the sterno-hyoid and the sterno-thyreoid muscles. Remember that the fibres of the sterno-hyoid are directed upwards and inwards, and those of the sterno-thyreoid upwards and outwards.

INCISED WOUNDS OF THE NECK.

Suicidal and homicidal wounds of the neck may be in one of four situations: (*a*) above the hyoid bone; (*b*) through the thyreo-hyoid space; (*c*) through the larynx; or (*d*) through the trachea.

(*a*) **Above the Hyoid Bone.**—It will be seen that wounds in this position would divide the muscles between the hyoid bone and the mandible, namely, the mylo-hyoid, genio-hyoid, digastric, hyoglossus, and genio-hyoglossus. Moreover, as the mylo-hyoid lies immediately beneath the mucous membrane of the mouth, the floor of that cavity is usually opened, and the lingual vessels severed. The lingual and hypoglossal nerves are also divided as they pass to the under surface of the tongue. The act of deglutition is impaired because of the injury to the elevators of the larynx.

(*b*) **Through the Thyreo-hyoid Space.**—This is the most common site of suicidal cut-throat. Incisions through this space, after dividing the depressors of the hyoid bone (sterno-hyoid, omo-hyoid, and thyreo-hyoid), and the thyreo-hyoid membrane, may detach the epiglottis and open the pharynx. In some cases the arytænoid cartilages are injured, and the cut may extend to the bodies of the vertebræ. The superior thyreoid artery is divided, and asphyxia may ensue from hæmorrhage into the respiratory passages, or from subsequent œdema of the glottis.

(*c*) **Through the Larynx.**—Here the cartilages of the larynx, the crico-thyreoid membrane, with its artery, the vocal cords, and the superior thyreoid artery may be divided.

(*d*) **Through the Trachea.**—When the wound is opposite the trachea, the depressor muscles of the

hyoid bone, the edge of the sterno-mastoid, the thyreoid body and its superior vessels, and, more rarely, the inferior thyreoid arteries and the recurrent laryngeal nerves are severed.

The carotid vessels are very seldom injured in suicidal cut-throat, owing partly to the protection afforded by the cartilages in the middle line and the sterno-mastoids laterally; also in suicidal attempts the head is generally retracted. This renders the larynx and trachea more prominent, and causes the great vessels to slide beneath the sterno-mastoid muscles. The great mobility of the vessels no doubt also serves as a protecting factor.

In the lower part of the neck additional dangers are found—namely, the entrance of air into the veins, with the consequent risk of air-embolism, and the extension of suppuration into the thorax beneath the pretracheal layer of the cervical fascia.

THE THYREOID AND PARATHYREOIDS.

In addition to its proper capsule, the thyreoid is enveloped by a sheath derived from the pretracheal layer of cervical fascia. This is firmly connected by fibrous strands to the trachea and larynx; and, accordingly, accompanies these structures in their movements during deglutition. A healthy thyreoid is yellowish-red in colour, and in adult males weighs, on an average, one to one and a half ounces; it is usually a little larger and heavier in females, a temporary increase being observable in pregnancy and during menstruation. The thyreoid develops from the lower end of an entodermal outgrowth from the primitive pharynx—the thyreo-glossal tract or duct (see Tongue). As usually described, the gland consists of two lateral lobes united across the middle line of the neck by a

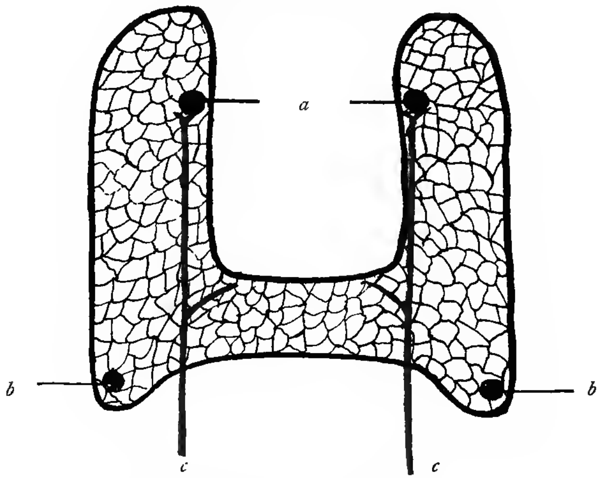
transverse commissure, the isthmus; this covers the second, third, and fourth tracheal rings. In many subjects (43 per cent., according to Marshall), a pyramidal lobe is present. It projects towards the hyoid bone from the upper border of the isthmus, and is more common on the left than on the right side. The pyramidal lobe is fixed to the hyoid either by the suspensory ligament or by a small muscular strip, the levator glandulæ thyreoidea.

The thyreoid body is covered by the sterno-hyoid sterno-thyreoid, omo-hyoid, and a portion of the sterno-mastoid. Behind are the trachea, the lower part of the larynx, the œsophagus (on the left), the pharynx, the carotid sheath with its contents, inferior thyreoid arteries, and the recurrent laryngeal nerves. The last mentioned relation must be especially remembered when extirpating the lower portion of the gland.

Blood-vessels and nerves.—The gland is exceedingly vascular, the arteries being the superior thyreoid from the external carotid, and the inferior thyreoid from the thyreoid axis branch of the subclavian. Occasionally a fifth artery is present, the thyreoidea ima branch of the innominate; if so, it supplies the isthmus. When the superior thyreoid reaches the apex of the lateral lobe, it splits into two, anterior and posterior. The former extends down the anterior border of the lobe, crosses the middle line along the upper margin of the isthmus, and anastomoses with its fellow of the opposite side. The posterior branch runs down the posterior border of the lobe to communicate with the inferior thyreoid. The inferior thyreoid curves downwards and inwards towards the lower extremity of the lobe. Here it divides into ascending and inferior, which mainly ramify upon the posterior surface of the gland. The

ascending branch anastomoses with the superior thyreoid, while the inferior communicates with the corresponding vessel of the opposite side. The superior and middle thyreoid veins drain the lateral lobes, cross the common carotid, and open into the internal jugular: the inferior thyreoid veins issue from the isthmus, and pass downwards to terminate,

Fig. 41.—Posterior Surface of Thyreoid Gland to show Position of Parathyreoids.



a, Superior parathyreoid (IV.); *b*, Inferior parathyreoid (III.); *c*, Inferior thyreoid artery.

generally by a single trunk, in the left innominate. Twigs from the middle and inferior ganglia of the cervical sympathetic furnish the nerve-supply for the gland.

Parathyreoids.—These minute bodies vary in number, size, and position. They are usually found in relation to the posterior surface of the thyreoid, embedded in its fascial sheath. Their dimensions

average 6 mm. long, 3 mm. wide, and 1.5 mm. in thickness. They are of a pale brown colour, with a consistence a little softer than that of a lymphatic gland. In the majority of cases two pairs are present, superior (Parathyreoid IV.), and inferior (Parathyreoid III.).

The *superior* are more constant in position than the inferior, being generally seen opposite the cricoid cartilage, and touching the lateral margins of the œsophagus. Lying along their inner side are the inferior thyreoid arteries and the recurrent laryngeal nerves.

The *inferior* pair are found on a level with the lower pole of the thyreoid; they may, however, occasionally be noticed anterior to the thyreoid. The parathyreoids develop from the entoderm lining the third and fourth inner branchial depressions, the inferior pair arising from the third depression, and being dragged down to their present position by the traction of the descending thymus. During goitre operations great care must be taken not to injure these little glands, or tetany will result.

THE LARYNX.

The framework of the larynx consists of nine cartilages united by membranes and ligaments; only five of these, however, are of surgical importance, namely, the thyreoid, the cricoid, the two arytænoids, and the epiglottis. Of the remaining cartilages, those of Santorini (cornicular) will be found upon the apices of the arytænoids, while those of Wrisberg (cuneiform) lie in the arytæno-epiglottic folds. In advanced life the thyreoid, cricoid, and arytænoids often become calcified. Such a process renders them extremely brittle and liable to fracture under slight pressure. In shape, the *cricoid* resembles a signet ring, with the broad end

supporting the arytænoids behind. The *arytænoids* are triangular, and have two salient processes—an external or muscular, and an anterior or vocal.

The *thyreoid* is made up of two alæ united anteriorly to form the pomum Adami. Each ala presents a couple of well-marked projections, the superior and inferior cornua. The alæ are attached to the body and great cornua of the hyoid by the thyreo-hyoid membrane, and to the cricoid by the crico-thyreoid membrane. Stretching from the superior cornua to the hyoid are the lateral thyreo-hyoid ligaments. Notice that the inferior cornua articulate with facets upon the lateral aspect of the cricoid. During deglutition, the upper portion of the thyreoid is drawn upwards behind the hyoid, a small bursa facilitating the movement.

The *epiglottis* consists of yellow elastic cartilage; it is leaf-shaped, the stalk being attached to the angle of the thyreoid. Studding its surface are numerous small pits lodging mucous glands. In addition to the thyreoid attachment, the epiglottis is fixed to the pharynx by the pharyngo-epiglottic folds, to the tongue by the glosso-epiglottic fold, to the hyoid bone by the hyo-epiglottic ligament, and to the arytænoids by the arytæno-epiglottic folds. Owing to the laxity of the connective tissue in the arytæno-epiglottic folds œdema is apt to distend them until they obliterate the upper aperture of the larynx. From the posterior surface of the epiglottis a small tubercle (the cushion) projects; it interferes with the view of the anterior commissure of the true vocal cords during a laryngoscopic examination.

Three divisions are found within the interior of the larynx—they are bounded by the false and true vocal cords. From the superior aperture (glottis) to the false cords is the vestibule, or sub-glottic space; from the false to the true cords is the ventricle, with two lateral

recesses—the laryngeal sinuses; and between the true cords and the commencement of the trachea is an unnamed area. A diverticulum of mucous membrane (the saccule) passes upwards for a variable distance from each sinus. Its secretion keeps the true cords moist.

The false vocal cords, or ventricular bands, are two pink, flaccid folds of mucous membrane containing mucous glands. They are covered by ciliated epithelium. Their free borders look downwards and inwards, the interval between them being termed the false glottis.

Examine the true vocal cords. They are the free ends of the lateral portion of the crico-thyreoid membrane, covered by mucous membrane, and stretch from the angle between the alæ of the thyreoid to the vocal processes of the arytænoids. They differ from the false cords in the following particulars: (*a*) they are yellow in colour, and very elastic; (*b*) their free edges point upwards and inwards; (*c*) glands are absent; and (*d*) their epithelial investment is of the pavement type.

Opposite the true cords will be found the *rima glottidis.* The anterior part of this space intervenes between the true cords, and accordingly is known as the *glottis vocalis*, while the posterior portion, the *glottis respiratoria* separates the arytænoid cartilages. On an average, the length of the rima glottidis in adult males is 23 mm., whereas in adult females it is 17 mm. During the emission of a high note when singing, the vocal cords and the apices of the arytænoids are approximated, and hence the glottis vocalis is considerably narrowed. On the contrary, when a deep inspiration is taken, the glottis vocalis widely dilates, and becomes somewhat lozenge-shaped.

Blood-vessels and Nerves.—Two arteries supply the larynx: the superior laryngeal from the superior

thyreoid, and the inferior laryngeal, a branch of the inferior thyreoid. The sensory nerve is the internal division of the superior laryngeal, a branch of the vagus. It enters the larynx, accompanied by the superior laryngeal artery, through the lateral portion of the thyreo-hyoid membrane, and runs beneath the floor of the sinus piriformis. This nerve must be carefully avoided during the operation of sub-hyoid pharyngotomy. The motor nerves are the external division of the superior laryngeal, and the recurrent laryngeal. The course of the latter nerve has been previously described; it enters the larynx along with the inferior laryngeal artery.

Table of the Main Intrinsic Muscles of the Larynx.

Muscle.	Nerve Supply.	Action.
Crico-arytænoideus posterior	Recurrent laryngeal.	Abductor of the vocal cords.
Crico-arytænoideus lateralis	Recurrent laryngeal.	Adductor of the vocal cords.
Crico-thyreoideus	External laryngeal	Tensor of the vocal cords.
Thyreo-arytænoideus	Recurrent laryngeal.	Relaxor of the vocal cords.
Arytænoideus	Recurrent laryngeal.	Approximates the arytænoids, and helps to close the glottis during deglutition.

POSTERIOR TRIANGLE OF THE NECK.

The posterior triangle is bounded in front by the posterior border of the sterno-mastoid; behind by the anterior edge of the trapezius, and below by the middle

third of the clavicle. In muscular individuals an apex is formed by the meeting of the sterno-mastoid and trapezius at the occiput. Crossing the triangle, and dividing it into two parts, is the posterior belly of the omo-hyoid; the large upper area is termed occipital, and the small lower division, subclavian or supra-clavicular.

The roof is formed by the skin, superficial fascia, platysma myoides, and deep fascia; the floor by the splenius capitis, levator anguli scapulæ, scalenus medius, scalenus posterior, and the first digitation of the serratus anterior (magnus), from above downwards.

Contents.—(*a*) Occipital triangle—
- Spinal accessory nerve.
- Cervical plexus and upper part of brachial plexus.
- Transversalis colli vessels.
- Lymphatic glands.

(*b*) Subclavian triangle—
- Third part of subclavian artery.
- Subclavian vein.
- Transversalis colli vessels.
- Suprascapular vessels.
- External jugular vein.
- Upper part of brachial plexus.
- Lymphatic glands.

Spinal Accessory Nerve.—The spinal accessory or eleventh cranial nerve consists of two portions—the spinal, and the accessory to the vagus. The former issues from the lateral aspect of the spinal cord as low down as the fifth cervical vertebra. It then ascends in the spinal canal between the ligamentum denticulatum and the posterior nerve roots, to enter the posterior cranial fossa through the foramen magnum. Having joined

with its accessory part (the superficial origin of which is the postero-lateral fissure of the medulla), it leaves the skull through the middle compartment of the jugular foramen, lying posterior to the tenth (vagus) and ninth (glossopharyngeal) nerves. It passes over the internal jugular vein, then beneath the posterior belly of the digastric and the stylo-hyoid muscles, and below the transverse process of the atlas, being crossed at this level by the occipital artery. The nerve now pierces the sterno-mastoid one and a half inches below the apex of the mastoid process, and emerging from the muscle opposite the middle of the posterior border, runs over the posterior triangle to ramify in the trapezius.

The spinal portion supplies the sterno-mastoid and the trapezius, communicating in the former muscle with the second cervical nerve, and in the latter with the third and fourth cervicals. The accessory part blends with the vagus, and is distributed along with its pharyngeal, laryngeal, and cardiac branches.

Irritation of the spinal accessory leads to a variety of torticollis, which may require section of the nerve. This is best accomplished by securing the nerve just before it enters the sterno-mastoid. The nerve is in danger during the removal of tuberculous glands from this region.

Cervical Plexus.—This plexus is formed by the anterior primary divisions of the upper four cervical nerves and lies under cover of the sterno-mastoid. The branches are divided into three sets—cutaneous, muscular, and communicating.

(*a*) *Cutaneous*—

Small occipital .	from the second cervical.
Great auricular .	from the second and third cervicals.
Superficial cervical .	from the second and third cervicals.

Acromial . . } from the third and fourth cervicals.
Clavicular . . }
Sternal . . }

The cutaneous nerves emerge in a group from beneath the middle of the posterior border of the sterno-mastoid. Remember that the third and fourth cervical branches supply the integument as low as the second intercostal space, and therefore in fracture-dislocation between the sixth and seventh cervical vertebræ sensation is retained in the area supplied by these branches.

(*b*) *Muscular*—

The first and second supply the anterior and lateral recti muscles.

The second supplies the sterno-mastoid.

The third and fourth supply the trapezius, levator anguli scapulæ, scalenus medius, and scalenus posterior.

The *phrenic nerve* is formed by branches from the third, fourth, and fifth cervical nerves. It crosses the scalenus anterior, goes behind the suprascapular and transversalis colli vessels, then over the subclavian artery and behind the subclavian vein. After passing in front of the internal mammary artery, it enters the superior mediastinum of the thorax. From there the nerve traverses the middle mediastinum, lying between the pericardium and the pleura, to pierce the diaphragm and break up on its under surface.

(*c*) *Communicating*—

The loop between the first and second gives off a twig to (a) the vagus, (b) the hypoglossal, and (c) the superior cervical ganglion of the sympathetic.

The second and third send a branch to the descendens hypoglossi, to form the ansa hypoglossi.

The second, third, and fourth communicate with (a) the spinal accessory, and (b) the superior cervical ganglion of the sympathetic.

The **External Jugular Vein** arises in the parotid gland by the junction of the posterior auricular and the posterior division of the temporo-maxillary. It crosses the sterno-mastoid obliquely, lying between the platysma and the deep fascia. In the lower part of the posterior triangle the vein pierces the deep fascia, passes anterior to the third part of the subclavian artery, and terminates in the subclavian vein. A large section of the vein is very closely related to the superficial cervical glands and so may be injured when extirpating the latter. Opening into the external jugular are the suprascapular, transversalis colli, posterior external jugular, and anterior jugular veins.

A line drawn from a point midway between the angle of the mandible and the apex of the mastoid process to the centre of the clavicle, will represent the surface anatomy of the vessel.

Subclavian Artery.—The course of the subclavian artery in the neck is indicated by a curved line from the sterno-clavicular articulation to the middle of the clavicle, the line extending three-quarters of an inch above the bone. The vessel forms an arch, which is divided into three parts by the scalenus anterior muscle, the second part passing behind the muscle.

The first and second parts of the artery lie deeply, are very difficult of access, and from the numerous large branches given off, are unsuitable for the application of a ligature.

The third part, *i.e.*, the part beyond the scalenus anterior, lies in the lower part of the posterior triangle and disappears beneath the clavicle. In this region the vessel may be compressed against the first rib, over

which it crosses; the pressure should be exerted almost vertically downwards.

Relations of the Third Part

Anterior

Integument, fasciæ, platysma, and clavicular branches of the cervical plexus.

External jugular vein with three tributaries—suprascapular, transversalis colli, and anterior jugular.

Clavicle, subclavius muscle, and nerve to subclavius.

Suprascapular artery.

Superior		*Inferior*
Posterior belly of omohyoid. Lower trunk of brachial plexus.	**A**	First rib.

Posterior

Lower trunk of brachial plexus.
Scalenus medius.

The subclavian vein is on an anterior plane to the artery and also at a lower level.

In ligature of the third part, the guides are: (i) the clavicle; (ii) the posterior border of the sternomastoid; (iii) the posterior border of the scalenus anterior; and (iv) the scalene tubercle on the first rib. The needle is passed from above downwards to avoid the lower trunk of the brachial plexus; in the case of no other artery is the needle passed towards the companion vein.

Branches of the Subclavian Artery

1st Part
- Vertebral
- Internal mammary
- Thyreoid axis
  - inferior thyreoid
  - transversalis colli
    - superficial cervical.
    - posterior scapular.
  - suprascapular

2nd Part	Superior intercostal	deep cervical. intercostal.
3rd Part	No branches normally, but in 30% of cases the posterior scapular arises from this part.	

The **Vertebral** ascends to the interval between the scalenus anterior and the longus colli, where it enters the costo-transverse foramen of the sixth cervical vertebra, just below the carotid tubercle. The artery is crossed by the inferior thyreoid, the vertebral vein, and on the left side, by the thoracic duct in addition. After traversing the costo-transverse foramina of the first six cervical vertebræ, the artery grooves the upper surface of the posterior arch of the atlas, pierces the posterior occipito-atlantoid ligament, and enters the cranium through the foramen magnum. Lastly, it perforates the dura mater and unites, at the lower border of the pons with its fellow of the opposite side to form the basilar.

Ligature of the artery has been performed for idiopathic epilepsy, and for basilar aneurysm. Owing to the proximity of the thoracic duct on the left, only the right artery can be tied. It is best reached by an incision along the lower third of the anterior border of the sterno-mastoid.

The **Inferior Thyreoid** is directed inwards, in a somewhat arched manner, behind the carotid sheath and its contents, and behind the cervical sympathetic nerve. Closely accompanying the artery in the latter part of its course is the recurrent laryngeal nerve. (*See* Thyreoid Body).

The main branches are thyreoid, tracheal, œsophageal and ascending cervical.

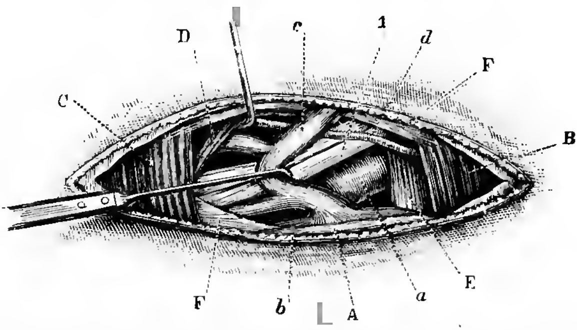
Formerly the artery was tied for vascular goitres, but with little success.

The **Transversalis Colli** passes outwards on the

scalenus anterior, the phrenic nerve, and the brachial plexus. It is crossed by the posterior belly of the omohyoid. Reaching the anterior border of the levator scapulæ, the transversalis colli divides into (*a*) posterior scapular, and (*b*) superficial cervical; the former descends along the vertebral border of the scapula between the serratus anterior and the rhomboidei.

The **Suprascapular** runs over the scalenus anterior, the phrenic nerve, and the third part of the subclavian

FIG. 42.—LIGATURE OF THE RIGHT SUBCLAVIAN ARTERY (THIRD PART). (After TREVES.)



A, Clavicle; B, Sterno-mastoid; C, Trapezius; D, Omo-hyoid; E, Scalenus anterior; F, Cervical fascia; *a*, Subclavian artery; *b*, Subclavian vein; *c*, External jugular vein; *d*, Transversalis colli; 1, Brachial plexus.

artery. Passing behind the clavicle it reaches the superior border of the scapula; here it crosses over the suprascapular ligament, and then enters the infraspinous fossa by going beneath the spino-glenoid ligament.

ANTERIOR TRIANGLE OF THE NECK.

The anterior triangle extends between the anterior border of the sterno-mastoid and the middle line of the neck; the base is formed by the lower jaw. The roof is made up of the skin, superficial fascia, platysma,

and the deep fascia. Between the platysma and the deep fascia is the *anterior jugular vein.* This vessel commences in the submaxillary gland by the union of some small venules. It runs along the anterior border of the sterno-mastoid, and reaching the clavicle, pierces the deep fascia, passes under the sterno-mastoid, and terminates in the external jugular. Incisions along the anterior border of the sterno-mastoid will encounter this vein.

The anterior triangle is subdivided into three smaller areas—muscular, carotid, and submaxillary.

Muscular Triangle.—*Boundaries*—above is the anterior belly of the omo-hyoid; behind, the anterior border of the sterno-mastoid; and in front, the middle line of the neck.

Contents.—Sterno-hyoid and sterno-thyreoid muscles.
Larynx, trachea, and œsophagus (on left side).
Thyreoid body and parathyreoids.
Terminations of superior and inferior thyreoid arteries.
Ansa hypoglossi, external laryngeal, and recurrent laryngeal nerves.

The *ansa hypoglossi nerve* supplies the depressor muscles of the hyoid bone—namely, the omo-hyoid, sterno-hyoid, and sterno-thyreoid. It is formed by the junction of the descendens hypoglossi from the hypoglossal, and the communicating branch from the cervical plexus (S. 2, 3).

The *recurrent laryngeal nerves* are branches of the vagi; the right nerve hooking round the first part of the subclavian artery, and the left nerve round the ligamentum arteriosum beneath the aortic arch. Each extends upwards behind the carotid sheath, accompanied by the inferior thyreoid artery, and then lies in the sulcus between the trachea and the œsophagus.

Both nerves enter the larynx by passing beneath the lower border of the inferior constrictor muscles.

Injury to the recurrent laryngeal sometimes occurs in goitre operations, and the left nerve is also in danger during lateral œsophagotomy. Paralysis of the nerve leads to hoarseness, or even to aphonia, as the recurrent laryngeal is the main motor nerve of the larynx. Aneurysms of the aortic arch, and tumours of the mediastinum may cause injurious pressure upon the left nerve.

Carotid Triangle.—*Boundaries*—above are the posterior belly of the digastric and the stylo-hyoid; behind, the anterior border of the sterno-mastoid; and below, the anterior belly of the omo-hyoid.

Contents.—The chief contents of this triangle are the—

Common carotid artery dividing into internal and external.

Superior thyreoid, ascending pharyngeal, lingual, facial, and occipital branches of the external carotid.

Internal jugular vein with certain of its tributaries—namely, the superior thyreoid, middle thyreoid, lingual, and common facial veins.

Glossopharyngeal, vagus, spinal accessory, hypoglossal, and cervical sympathetic nerves.

Superior laryngeal branch of the vagus with its internal and external divisions.

Lymphatic glands and the carotid body.

Common Carotid Artery.—In the neck, the common carotid artery on each side extends from the sterno-clavicular articulation to the upper border of the thyreoid cartilage, which is opposite the third cervical intervertebral disc. The course of the artery is represented by a line drawn from the articulation to a

point midway between the angle of the mandible and the apex of the mastoid process. At the lower part of the neck, the arteries are deeply placed, and are merely separated by the width of the trachea. As they pass upwards they become more superficial, and diverge from each other. Opposite the cricoid cartilage the anterior belly of the omo-hyoid crosses the common carotid. The artery is usually ligatured above this level, in the angle between the anterior border of the sterno-mastoid and the anterior belly of the omo-hyoid. The common carotid, along with the internal jugular vein and the vagus nerve, is encloesd in a special sheath derived from the deep cervical fascia.

Relations—(*a*) Above the omo-hyoid :—

Anterior

Skin, superficial fascia, platysma, and deep fascia.
Anterior border of sterno-mastoid.
Artery to sterno-mastoid, a branch of the superior thyreoid.
Superior and middle thyreoid veins.
Descendens hypoglossi nerve.

External		*Internal*
Vagus nerve.	**A**	Larynx.
Internal jugular vein.		Pharynx.
		Thyreoid body.

Posterior

Cervical sympathetic.
Prevertebral muscles.
Prevertebral fascia.
Transverse processes of cervical vertebræ.

(*b*) Below the omo-hyoid :—

Anterior

Skin, superficial fascia, platysma, and deep fascia.
Sterno-mastoid, sterno-hyoid, and sterno-thyreoid.
Descendens hypoglossi nerve.
Thyreoid body.

External		*Internal*
Vagus nerve. Internal jugular vein.	**A**	Œsophagus (on left). Trachea. Thyreoid body. Recurrent laryngeal nerve. Inferior thyreoid artery.

Posterior

Cervical sympathetic.
Prevertebral fascia and muscles.
Transverse processes of cervical vertebræ.
Recurrent laryngeal nerve.
Inferior thyreoid artery.

In wounds of the common carotid above the cricoid cartilage, hæmorrhage can be controlled by digital pressure against the transverse process of the sixth cervical vertebra (carotid tubercle). To carry out this procedure, press outwards and backwards beneath the anterior border of the sterno-mastoid at the level of the cricoid.

Ligature of Common Carotid—The seat of election is opposite the cricoid cartilage. An incision is made along the anterior border of the sterno-mastoid, with its centre at this level. After dividing the superficial structures, the sterno-mastoid is retracted and its artery secured. Search is then made for the descendens hypoglossi, and when found it is carefully drawn aside. The sheath is opened on its inner aspect, and the needle passed from without inwards. Unless great care be

exercised, the vagus or the cervical sympathetic will be included in the ligature.

External Carotid Artery.—This vessel passes from the upper border of the thyreoid cartilage to the neck of the mandible, where it divides into the superficial temporal and the internal maxillary branches. The artery is usually tied opposite the great cornu of the hyoid bone, the ligature being applied between the superior thyreoid and lingual branches, care being taken of the internal laryngeal nerve which lies behind the external carotid at this level.

Relations :—

Anterior

Skin, superficial fascia, platysma, and deep fascia.
Anterior border of sterno-mastoid.
Stylo-hyoid and posterior belly of digastric.
Hypoglossal nerve.
Lingual and common facial veins.
Parotid gland, with facial nerve and temporo-maxillary vein in its substance.

External		*Internal*
Internal carotid.	**A**	Pharynx.
		Hyoid bone.

Posterior

Stylo-pharyngeus and styloid process.
Glosso-pharyngeal and internal laryngeal nerves.
Internal carotid.

The guides for ligature are, in order :—(*a*) the great cornu of the hyoid bone; (*b*) the anterior border of the sterno-mastoid; (*c*) the posterior belly of the digastric and the stylo-hyoid; and (*d*) the hypoglossal nerve.

Branches.—From the external carotid the following branches are given off:—superior thyreoid, ascending pharyngeal, lingual, facial, occipital, posterior auricular, superficial temporal, and internal maxillary.

Table of Branches of the External Carotid

Branch.	Direction.	Site of Origin.
Superior thyreoid	Inwards and forwards	½ inch below great cornu of hyoid.
Lingual . .	Inwards and forwards	Opposite great cornu of hyoid.
Facial . . (External maxillary)	Inwards and forwards	½ inch above great cornu of hyoid.
Internal maxillary . .	Inwards and forwards	Opposite neck of mandible.
Occipital . .	Outwards and backwards	Opposite origin of facial artery.
Posterior auricular . . .	Outwards and backwards	On a level with angle of mandible.
Ascending pharyngeal . .	Upwards	½ inch below great cornu of hyoid.
Superficial temporal . .	Upwards	Opposite neck of mandible.

The superior thyreoid, lingual, facial, superficial temporal, and internal maxillary branches have been already described.

The **Ascending Pharyngeal** passes upwards between the internal carotid and the wall of the pharynx, resting upon the transverse processes of the vertebræ, the prevertebral muscles, and the cervical sympathetic.

Arising in the parotid gland, the *posterior auricular* branch runs along the upper border of the posterior belly of the digastric to the groove between the mastoid process and the pinna, where it comes into relation with the posterior auricular nerve. The artery divides into mastoid and auricular branches.

The **Occipital** artery extends upwards and backwards, under shelter of the lower border of the posterior belly of the digastric, to the interval between the mastoid and the transverse process of the atlas. To reach this

interval, the artery crosses in front of the internal carotid, the vagus, the internal jugular, the hypoglossal, and the spinal accessory. In the second part of its course the occipital occupies a sulcus on the under surface of the temporal, and rests upon the rectus capitis lateralis. Lastly, it passes over the superior oblique and the complexus, either to pierce the trapezius, or appear between this muscle and the sterno-mastoid, where it accompanies the great occipital nerve in the scalp. The branches of the occipital artery are inconstant, with the exception of the princeps cervicis; this anastomoses with the vertebral above, and the superficial and deep cervicals below.

Internal Jugular Vein.—The vein begins at the jugular bulb, in the posterior compartment of the jugular foramen, lying behind the internal carotid artery and the glossopharyngeal, vagus, and spinal accessory nerves. It enters the carotid sheath, passing down the outer side of the internal and common carotid, and ultimately unites with the subclavian vein to form the innominate. The tributaries of the internal jugular are, the inferior petrosal sinus, the pharyngeal, common facial, lingual, and superior and middle thyreoid veins.

Internal Carotid Artery.—This artery arises from the bifurcation of the common carotid opposite the upper border of the thyreoid cartilage. Its course is so complex that it is usually described under three headings—(*a*) the cervical, (*b*) the petrous, and (*c*) the intracranial portions.

Cervical Stage.—The artery passes almost vertically upwards, lying on the outer side of the external carotid, and then behind it. The chief relations are :—

Anterior.

Skin, fasciæ, and platysma.
Anterior border of sterno-mastoid.
Posterior belly of digastric and stylo-hyoid.
Hypoglossal nerve.
Occipital and posterior auricular arteries.
External carotid artery *and between it and the internal carotid—*
Stylo-glossus and stylo-pharyngeus.
Glosso-pharyngeal and pharyngeal branch of vagus.
Stylo-hyoid ligament.

External		*Internal*
Internal jugular vein. Vagus nerve.	**A**	Ascending pharyngeal artery. Pharynx.

Posterior.

Prevertebral muscles and fascia.
Transverse processes of first three cervical vertebræ.
Cervical sympathetic.

Petrous Stage.—Entering the carotid canal, the artery runs directly upwards, then forwards and inwards to reach the middle cranial fossa through the foramen lacerum medium. The close relationship of the artery and the Gasserian (semilunar) ganglion was mentioned previously.

Intracranial Stage—The artery runs towards the posterior clinoid process, and then traverses the inner wall of the cavernous sinus accompanied by the abducens nerve. Opposite the anterior clinoid process it pierces the dura-mater and divides into its terminal branches. (*See* circle of Willis).

Submaxillary Triangle.—*Boundaries*—above is the body of the lower jaw, and an imaginary line drawn backwards to the sterno-mastoid; below and in front is

the anterior belly of the digastric, while below and behind are found the posterior belly of the digastric and the stylo-hyoid.

Contents—(*a*) The anterior part of the triangle, *i.e.* the portion *in front* of the stylo-maxillary ligament:—

Submaxillary gland.
Facial artery and vein.
Mylo-hyoid artery and nerve.
Hypoglossal nerve.
Lymphatic glands.

(*b*) The posterior part of the triangle, *i.e.* the portion *behind* the stylo-maxillary ligament:—

Lower part of the parotid gland.
External carotid artery.
Posterior auricular vessels.

The **Hypoglossal Nerve** has its superficial origin from the front of the medulla between the pyramid and the olivary body, and leaves the cranium through the anterior condyloid foramen. It enters the neck behind the internal jugular vein, and the internal carotid artery. At first, the nerve is closely united by fibrous tissue to the ganglion on the trunk of the vagus, and here an interchange of fibres occurs. The hypoglossal next passes downwards between the internal carotid and the internal jugular, and goes beneath the posterior belly of the digastric and the stylo-hyoid. It then hooks round the occipital artery, crosses the external carotid and the first part of the lingual, and enters the submaxillary triangle beneath the intermediate tendon of the digastric. In this triangle the nerve disappears under the mylo-hyoid, resting upon the hyoglossus just below Wharton's duct, and reaches the tongue lying internal to the lingual artery.

In view of the fact that intractable cases of facial nerve paralysis are now surgically treated by anastomosing the facial and the hypoglossal, the relations of these nerves must be carefully studied.

As the hypoglossal turns round the occipital artery it gives off its descending branch. This passes down on the anterior aspect of the carotid sheath, and unites with the communicating branch from the second and third cervical nerves to form the ansa hypoglossi. The following muscles are supplied by the hypoglossal:—Linguales, genio-hyoglossus, stylo-glossus, hyoglossus, genio-hyoid, thyreo-hyoid, sterno-hyoid, sterno-thyreoid, omo-hyoid. The genio-hyoid and the thyreo-hyoid are really supplied by the first and second cervical nerves, through the loop of communication between those nerves and the hypoglossal.

The descendens hypoglossi likewise receives its fibres from this loop, and as the sterno-hyoid, sterno-thyreoid, and omo-hyoid are innervated by the ansa hypoglossi, their nerve supply is derived from the first three cervicals.

Deep Cervical Fascia.—The superficial layer of the deep cervical fascia passes forwards from the ligamentum nuchæ to reach the posterior margin of the trapezius. Here it divides into two lamellæ, which ensheath the muscle and fuse at its anterior border. From this point the fascia forms the roof of the posterior triangle, then splits to enclose the sterno-mastoid, reunites, and extends over the anterior triangle, becoming continuous with the fascia of the opposite side. In the middle line it is firmly attached to the hyoid bone.

Vertically, the superficial layer can be traced upwards to—(*a*) the superior curved line of the occiput; (*b*) the mastoid process; (*c*) over the parotid gland to the zygoma; and (*d*) along the inferior aspect of the

mandible from the angle to the symphysis menti. Below, the fascia gains attachment to—(*a*) the scapular spine; (*b*) the acromion process; (*c*) the clavicle; and (*d*) the manubrium sterni.

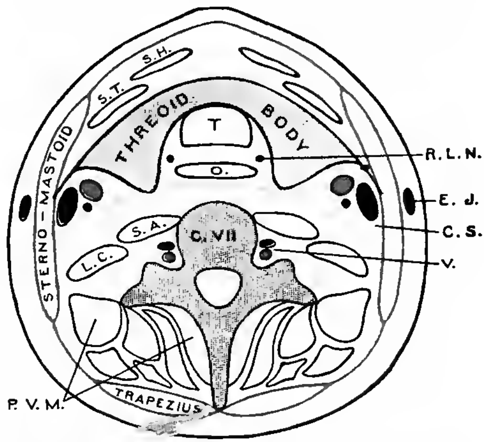
Two additional points must be noted regarding the arrangement of the superficial layer in the anterior triangle. In the first place, from the hyoid bone to the mandible the fascia envelopes the submaxillary gland; and secondly, about two inches above the suprasternal notch, the fascia cleaves into two lamellæ, leaving a triangular interval—the space of Burns. This space contains the sternal heads of the sterno-mastoid, one or two small lymphatic nodes, and the transverse connecting branch of the anterior jugular veins.

Two deep strata, the pretracheal and the prevertebral layers, require special attention. They spring from the lamella lining the deep surface of the sterno-mastoid and pass across the front of the neck to the opposite sterno-mastoid. The pretracheal layer lies anterior to the trachea and œsophagus, and, as we have already seen, provides a sheath for the thyreoid body. It extends vertically from the hyoid bone to the pericardium. The prevertebral layer covers the prevertebral muscles and the vertebral column. Above, it is fixed to the base of the skull; below, it passes over the longus colli into the thorax, and laterally over the brachial plexus and subclavian vessels to become the axillary sheath. (*See* Axilla.)

The carotid sheath is a special investment formed by the pretracheal and the prevertebral partitions. Enclosed within the sheath are the common carotid artery, the internal jugular vein, the vagus nerve (between the vessels and on a posterior plane), and sometimes the descendens hypoglossi nerve. The cervical sympathetic will usually be found sticking on the posterior wall.

The various processes of the cervical fascia divide the neck into three compartments—(*a*) the *muscular*, between the superficial and the pretracheal layers, containing the depressor muscles of the hyoid bone, namely, the sterno-hyoid, sterno-thyreoid, and the omo-hyoid; (*b*) the *visceral*, between the pretracheal

Fig. 43.—Diagram of the Cervical Fascia.



CS. Carotid Sheath.	RLN. Recurrent Laryngeal Nerve.
EJ. External Jugular.	SA. Scalenus Anterior.
LC. Longus Colli.	SH. Sterno-hyoid.
O. Œsophagus.	ST. Sterno-thyreoid.
PVM. Post-vertebral Muscles.	T. Trachea.

V. Vertebral Vessels.

and the prevertebral layers, containing the larynx, pharynx, œsophagus, trachea, thyreoid body, inferior thyreoid arteries, and recurrent laryngeal nerves; and (*c*) the *vertebral* compartment, behind the prevertebral layer, containing the prevertebral muscles and the cervical sympathetic, the vertebral vessels,

the spinal canal with its contents, and the posterior vertebral muscles.

It will be noticed that the visceral compartment encloses the main structures of the neck, and hence suppuration occurring in this region is very dangerous. The pus may gravitate into the superior mediastinum or into the axilla. Abscess beneath the prevertebral layer usually results from Pott's Disease of the cervical vertebræ, and is best evacuated by an incision along the posterior border of the sterno-mastoid.

THE LYMPHATIC DRAINAGE OF THE HEAD AND NECK.

Cervical Stage of the Thoracic Duct.—The thoracic duct leaves the thorax along the left margin of the œsophagus, under cover of the left common carotid artery. In the neck it passes upwards and outwards in an arched manner behind the left carotid sheath, then over, or behind, the vertebral vein, and crosses the phrenic nerve and scalenus anterior. Lastly, it curves downwards, forwards, and inwards, over the first part of the subclavian artery, to the junction of the left internal jugular and left subclavian veins. The summit of the arch usually reaches the level of the transverse process of the seventh cervical vertebra.

Near its termination, the thoracic duct is joined by the jugular trunk ; this is formed by the efferent vessels of the deep cervical nodes.

Parsons and Sargent have shown that in almost 50 per cent. of cases the thoracic duct divides at the root of the neck into two branches of about equal size, though when they are unequal the upper is usually the larger.

The right lymphatic trunk possesses no surgical interest.

Lymphatic Nodes.—The site, drainage area, and termination of the more constant nodes which are of surgical importance, are given in the accompanying table—

NAME.	SITE.	DRAINAGE AREA.	TERMINATION.
Occipital . .	Upon trapezius at base of occiput	Occipital region of scalp	Superficial cervical chain, and superior group of deep cervical chain.
Mastoid . .	Upon mastoid attachment of sterno-mastoid	Posterior surface of pinna, and external auditory meatus; temporal region of scalp	Similar to occipital glands.
Buccal . .	On buccinator, opposite angle of mouth	Cheek and side of face	Parotid, and submaxillary glands.
Preauricular .	Immediately in front of tragus, beneath parotid fascia	Anterior surface of pinna, and external auditory meatus; temporal region and outer portion of eyelids	Superior group of deep cervical chain.
Parotid . .	In substance of parotid gland	Similar to preauricular group; also the nose, soft palate, and buccal glands	Submaxillary, and superior group of deep cervical chain

Nerve.	Site.	Drainage Area.	Termination.
Facial . .	Upon lower border of mandible, at anterior edge of masseter	Nose, cheek, and upper lip	Submaxillary glands.
Submental .	In submental triangle—*i.e.* between the anterior bellies of the digastric and the hyoid bone	Chin ; central part of lower lip and mandible ; floor of mouth, and tip of tongue	Submaxillary, or deep cervical chain.
Submaxillary .	Over submaxillary gland	Anterior part of tongue, floor of mouth ; alæ nasi ; upper lip ; lower lip ; gums and teeth	Superior group of deep cervical chain.
Retro-pharyngeal	In bucco-pharyngeal fascia, on a level with atlas	Naso-pharynx and nasal mucous membrane ; Eustachian tube and tympanum	Superior group of deep cervical chain.

The superficial cervical chain (glandulæ concatenatæ) is associated with the external jugular vein, and therefore found more or less along the posterior border of the sterno-mastoid. The glands lie superficial to the cervical fascia. Their efferent ducts terminate in the lower deep cervical group. When removing the glands for tubercle, remember the close proximity of the external jugular vein.

The deep cervical chain is found beneath the superficial layer of cervical fascia, along the anterior border of the sterno-mastoid, and accompanying the internal jugular vein. It is arranged in two groups—superior and inferior; each of which is subdivided into medial and lateral. The medial lie superficial to the internal jugular, and when enlarged project into the anterior triangle; the lateral groups are postero-external to the vein resting upon the splenius and the levator scapulæ muscles, and are therefore in close relation to the spinal accessory nerve. The superior set extends from the base of the skull to the bifurcation of the common carotid artery; it drains the areas mentioned in the table, also the tonsil, the posterior third of the tongue, the upper part of the larynx, and the thyreoid body. The most important node of this series is one found in the angle between the internal jugular and common facial veins. It becomes enlarged in malignant disease of the posterior part of the tongue and the tonsil.

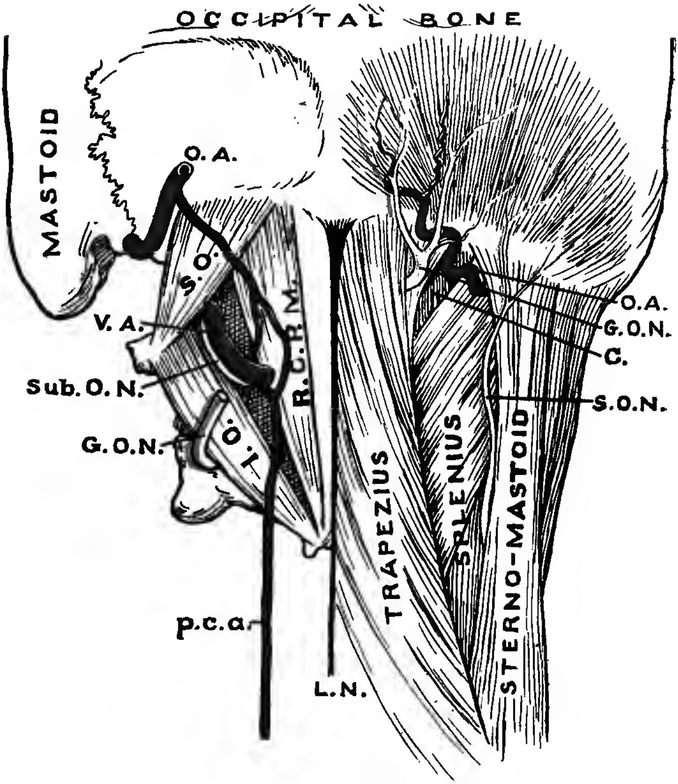
The inferior group receives afferents from the upper group, the superficial cervical chain, the lower part of the larynx, and the cervical portion of the œsophagus and trachea. Its efferents unite as the jugular trunk, which opens into the thoracic, or the right lymphatic duct.

THE SUBOCCIPITAL REGION.

The modern surgical treatment of spasmodic torticollis consists in dividing the spinal accessory nerve on the side of the wryneck, and in resecting portions of the posterior primary divisions of the first four or five cervical nerves on the opposite side. The posterior primary division of the first cervical occupies the suboc-

cipital triangle; it is entirely a motor nerve, being distributed to the neighbouring muscles. In order to

Fig. 44.—The Suboccipital Region.



C. Complexus.
G.O.N. Great Occipital Nerve.
I.O. Inferior Oblique.
L.N. Ligamentum Nuchæ.
O.A. Occipital Artery
P.C.A. Profunda Cervicis Artery.
R.C.P.M. Rectus Capitis Posterior Major.
S.O. Superior Oblique.
S.O.N. Small Occipital Nerve.
Sub.O.N. Sub-Occipital Nerve
V.A. Vertebral Artery.

reach the remaining cervical nerves operated upon, it is necessary to trace their sensory (internal) branches

inwards through the semi-spinalis colli muscle until the posterior primary divisions are reached. The suboccipital nerve lies immediately above the inferior oblique: the great occipital (the internal branch of the posterior primary division of the second cervical) skirts the lower border of this muscle, while the internal branches of the third, fourth, and fifth cervical nerves emerge through the semispinalis colli along a vertical line from the great occipital (Fig. 44). In exposing the suboccipital triangle the following muscles are divided:—the trapezius, the splenius capitis, and the complexus. The occipital artery lies upon the complexus, and its princeps cervicis branch anastomoses with the superficial cervical and the deep cervical on the posterior and anterior surfaces of the complexus respectively.

Suboccipital Triangle.—This triangle is bounded above and externally by the superior oblique, below and externally by the inferior oblique, and internally by the rectus capitis posterior major. The floor is formed by the posterior part of the arch of the atlas, and the posterior occipito-atlantoid ligament. In addition to the suboccipital nerve, the triangle contains the vertebral artery and the suboccipital veins; the latter are tributaries of the deep cervical, which opens into the vertebral vein.

The superior oblique arises from the transverse process of the atlas, and is inserted into the occipital bone above the inferior curved line; the inferior oblique passes from the spine of the axis to the transverse process of the atlas, while the rectus capitis posterior major extends from the spine of the axis to the occipital bone, internal to and below the attachment of the superior oblique. All three muscles are supplied by the suboccipital nerve.

SECTION IV.

THE SPINE.

Nuchal Groove.—The nuchal groove is a median furrow found in the cervical region. It is bounded laterally by the complexus, and overlies the ligamentum nuchæ. On palpation the spinous processes of the axis, the sixth and seventh cervicals, and the first dorsal can be detected. The dorsal prominence is usually the most conspicuous. The spines lie opposite the lower border of their corresponding bodies.

Spinal Groove.—This sulcus is found in the dorsal and lumbar regions, and is due to the erector spinæ on each side. Along its track the dorsal and lumbar spines should be palpated. Each of the spines of the lower ten dorsal vertebræ is on a level with the body of the vertebra below.

Limits of Vertebral Column.—When the subject is in the erect position, the upper limit corresponds to a horizontal line at the level of the free margin of the upper lip; the lower limit to a horizontal line at the upper part of the symphysis pubis.

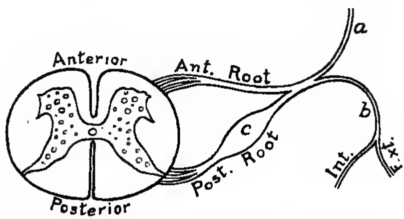
Lumbar Puncture.—Lumbar puncture is usually performed either through the interval between the third and fourth, or the fourth and fifth lumbar spines. The patient should bend forwards with the head between the knees, so as to open out the interspaces. The site is found by—(*a*) drawing a horizontal line connecting the highest point of each iliac crest; (*b*) bisecting the line; and (*c*) taking a point half an inch above (for the third interspace) or half an inch below the bisection (for the fourth interspace). If the needle is introduced in the

middle line, the supraspinous and interspinous ligaments must be traversed ; if a little to one side, the ligamentum subflavum is encountered.

Direct the needle forwards and slightly upwards. The arachno-pial space, in the meshes of which the cerebro-spinal fluid will be reached, lies at a distance of two inches from the surface. The first drops of fluid may be blood-stained owing to the puncture of one of the extra-dural veins.

Spinal Cord.—The spinal cord terminates in the conus medullaris, which in adults lies opposite the first lumbar spinous process ; in children it descends as low

Fig. 45.—A Typical Spinal Nerve.



a. Anterior primary division. *b.* Posterior primary division. *c.* Ganglion,

as the third lumbar spine. The cervical enlargement ends at the level of the sixth cervical spine, whilst the lumbar enlargement commences opposite the tenth thoracic spine.

Thirty-one pairs of spinal nerves issue from the cord ; they are made up of eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal. Each nerve is formed by the junction of the anterior and posterior nerve roots of the corresponding segment of the spinal cord. After a short course the nerves divide into anterior and posterior primary divisions. With the exception of the first cervical, the fourth and fifth sacrals and the coccygeal, the posterior primary divisions split

into an internal and an external branch. Down to the sixth dorsal, the internal branches are sensory and the external motor; below this level the order is reversed. The posterior primary divisions, however, of the sixth, seventh, and eighth cervicals, and the fourth and fifth lumbars are entirely motor.

The spinal segments do not lie opposite the corresponding spinous processes. In the cervical region the segment is one lower than the spinous process, *e.g.*, the fifth cervical spine is on a level with the sixth cervical segment. The upper five thoracic segments are two lower than the spinous processes, and the remaining thoracic segments three lower, *e.g.*, the third thoracic spine is opposite the fifth segment, and the ninth spine is opposite the twelfth segment. All the lumbar segments are found between the tenth and twelfth thoracic spines, while the sacral and coccygeal segments correspond to the first lumbar spine.

Table of the Chief Muscles with the Segments supplying them.

Muscles.	Segments.
Deltoid and Spinati	C. 5.
Biceps, Brachio-radialis and brachialis	C. 6.
Triceps and extensors of wrist and fingers	C. 7.
Flexors of wrist and long flexors of fingers	C. 8.
Intrinsic muscles of hand	T. 1.
Intercostals	T. 2-10.
Abdominal	T. 7-L. 1.
Ilio-psoas	L. 1-2.
Quadriceps	L. 3.
Adductors of thigh	L. 4.
Hamstrings	L. 5.
Calf muscles	S. 1.
Glutæi and intrinsic muscles of sole	S. 2.
Peronæal muscles	S. 3-5.

According to the researches of Head, the spinal segments connected with the chief thoracic and abdominal viscera are—

Lungs. C. 3. 4; T. 3. 4. 5. 6. 7. 8. 9.
Heart. T. 2. 3. 4. 5. 6. 7. 8.
Stomach. C. 4; T. 6. 7. 8. 9. 10 (?).
Intestines. T. 9. 10. 11. 12.
Lower part of large bowel. S. 2. 3. 4.
Liver and gall-bladder. T. 7. 8. 9. 10.
Kidney and Ureter. T. 10. 11. 12; L. 1. 2 (?).
Bladder. T. 11. 12; L. 1; S. 2. 3. 4.
Prostate. T. 10. 11; S. 1. 2. 3.
Testis. T. 10. 11. 12; L. 1 (?).

Section of the posterior nerve roots is frequently undertaken for such conditions as spastic paralysis, the gastric crises of tabes, and to relieve pain in inoperable spinal tumours.

In spastic paralysis affecting the upper extremity, the posterior roots from the fifth cervical to the second thoracic on both sides are divided; for spastic paraplegia all the lumbar and sacral posterior roots should be severed. Gastric crises can be prevented by section of the posterior roots from the fifth to the twelfth thoracic, both inclusive.

Meninges.—These extend down to the second or third sacral spines. The spinal dura mater has not the same intimate relation to the bones surrounding it as the cranial dura mater has, consequently trauma of the vertebræ is not always followed by damage to, or inflammation of the spinal membranes, as is so frequently the case in head injuries.

The cord and its membranes may be injured by punctured wounds in the cervical region, where the laminæ are horizontal, and separated by slight intervals;

or the cord may be reached through the occipito-atlantoid space.

In the thoracic region the laminæ overlap each other, so as to form a shield, which, in the absence of fracture, effectually protects this part of the cord from being punctured.

The *cerebro-spinal fluid* is found within the subarachnoid trabeculæ. It surrounds the exterior of the cord and fills the medullary canal, the communications between the two spaces, the foramina of Majendie and Key and Retzius being situated in the roof of the fourth ventricle.

Curvature of the Spine.—In the adult the spine has normally four curves—viz., convex forwards in the cervical and lumbar regions, and convex backwards in the thoracic and sacral regions.

At birth the spine has one simple curve with its convexity backwards. The secondary curves having their convexity forwards appear later, that in the cervical region being the first to develop.

These antero-posterior curvatures may become exaggerated, constituting the deformities known as kyphosis and lordosis, and having their convexities backwards and forwards respectively.

In lateral curvature, or scoliosis, the spine usually presents three curves—a primary and two compensatory curves. In the most common form the convexity is towards the right in the thoracic region, and towards the left in the cervical and lumbar regions. Scoliosis is almost always accompanied by a rotation of the bodies of the vertebræ so that the spinous processes, laminæ, and articular processes, look towards the concavity of the curve. Hence the amount of lateral deviation of the spinous processes is rather misleading, as it does not show the true amount of deviation of the vertebral

bodies. In an advanced typical case (*i.e.*, with the thoracic convexity directed towards the right), the following points should be noticed: (*a*) the intercostal spaces are widened on the side of the convexity and crowded together on the concave side; (*b*) the muscles and ligaments are elongated on the convex side and shortened on the concave side; (*c*) the right scapula is pushed backwards and its inferior angle elevated; (*d*) the right shoulder is on a higher level than the left one; (*e*) the right half of the thorax bulges behind and is flattened in front; (*f*) the left half of the thorax projects anteriorly and is flattened behind; (*g*) a deep furrow between the costal margin and the iliac crest on the left side; (*h*) the brachio-thoracic triangle is more marked on the left; (*i*) more or less displacement of the thoracic viscera.

Movements of the Spine.—The spine is capable of extensive movement, both in the antero-posterior and lateral directions, together with a considerable amount of rotation on a vertical axis.

The thoracic region is the least movable part of the spine, this being due to the overlapping of the spinous processes and laminæ.

The lumbar region is the most mobile part of the spine—antero-posterior, lateral, and rotatory movements being allowed.

In the cervical region, while flexion and extension are curtailed, the lateral and rotatory movements are very free.

"The point most exposed to injury is the union of the dorsal and lumbar curves, where the column of the trunk is the most movable, has the least transverse width, and is acted on by longer leverage than elsewhere" (Macalister).

Ligaments of the Spine.—The anterior common

ligament extends from the sacrum to the axis. It is firmly attached to the intervertebral discs. The posterior common ligament has a similar extent, and opposite each intervertebral disc it is fixed to the adjacent margins of the vertebræ, and also to the disc. Two ligaments unite the spinous processes, the supraspinous and the interspinous; in the cervical region, the ligamentum nuchæ replaces the supraspinous ligaments. The ligamenta subflava are attached to the contiguous margins of the laminæ, while the articular processes are surrounded by capsular ligaments. Pay special attention to the bands connecting the atlas, axis, and occiput. Those of prime surgical importance are the cruciform and the three odontoid ligaments. The cruciform consists of a transverse and a vertical portion; the former is a strong band connecting the inner tubercles of the atlas, and passing behind the odontoid process. Together with the anterior arch of the atlas, it completes the ring for the pivot formed by the odontoid. The vertical part is made up of two crura, which fix the transverse element to the basilar process of the occipital, and to the body of the axis. From the odontoid process three bands extend to the occipital, two lateral or check ligaments, and a middle or suspensory. The check ligaments are attached to the inner surfaces of the occipital condyles; they limit rotation of the head.

Spina Bifida.—This is a congenital malformation due to incomplete development of the laminæ and spinous processes of certain vertebræ, allowing of the protrusion of certain of the contents of the vertebral canal in the form of a fluctuating swelling.

In the fœtus the vertebral canal exists in the form of an open groove. This is eventually closed in by the backward growth of the laminæ, which coalesce posteriorly to form the spinous processes.

The fusion occurs first in the cervical region, next in the thoracic region, and last of all in the lumbar and sacral regions. Accordingly, spina bifida is most commonly met with in the lumbar and lumbo-sacral areas. The membranes and cerebro-spinal fluid may protrude (*spinal meningocele*); or the membranes with some of the spinal nerves (*meningo-myelocele*); or the cord with a dilated medullary canal (*syringo-myelocele*); or the integument may be absent, and the cord remain entirely unprotected (*myelocele*). In certain cases there is no protrusion of the spinal contents, a form known as *spina bifida occulta.* It is of clinical importance to remember that a meningeal lipoma frequently overlies a spina bifida occulta.

SECTION V.

THE ABDOMEN.

THE ABDOMINAL PARIETES.

On inspection, a series of tendinous inscriptions, limiting the extent of the recti muscles, demands attention. Three of them are arranged longitudinally, the linea alba and the lineæ semilunares; three run horizontally, the lineæ transversæ. The linea alba descends in the mesial line from the xiphoid process to the upper border of the symphysis pubis, although it is not visible below the umbilicus. It is made up of the fused aponeuroses of the obliques and transversales muscles, and above the umbilicus consists mainly of horizontal fibres. Between these fibres a portion of extra-peritoneal fat may emerge, forming an epigastric hernia. The surgeon frequently opens the abdominal cavity through this line, as it is comparatively bloodless. In so doing the following strata are encountered (*a*) integument, (*b*) aponeuroses of the muscles, (*c*) fascia transversalis, (*d*) extra-peritoneal fat, and (*e*) parietal peritoneum.

Each linea semilunaris stretches from the tip of the ninth costal cartilage to the pubic spine, the convexity of its curve being directed outwards. Incisions through this line have the disadvantage of severing the lower intercostal nerves, which form the motor supply of the rectus.

The lineæ transversæ are adherent to the anterior layer of the sheath of the rectus. Notice that the upper line is opposite the xiphoid process, the lower on a level with the umbilicus, whilst the intermediate one falls midway between these points.

The umbilicus is interesting surgically, as it may form (*a*) the site of an umbilical hernia; (*b*) the orifice of a urinary fistula due to a patent urachus; (*c*) the outlet of a fæcal fistula, caused either by disease, or by an unobliterated vitelline duct.

In certain cases of hepatic cirrhosis, the superficial veins in the neighbourhood of the umbilicus become exceedingly tortuous and distended. This is owing to the portal circulation affecting an anastomosis with the superficial umbilical veins along the accessory vein of Sappey, the latter being a small vessel accompanying the ligamentum teres of the liver.

Patients who have borne children present numerous whitish streaks, due to overstretching of the integument in the area between the umbilicus and the pubes; they are known as striæ gravidarum.

The superficial fascia of the abdomen is at its lower part divisible into two layers—a fatty stratum, the fascia of Camper, and a deep membranous layer, the fascia of Scarpa. Continuous with the fascia of Colles of the perineum, the fascia of Scarpa is intimately adherent to the fascia lata of the thigh just below the inguinal (Poupart's) ligament. This attachment effectually prevents any extravasated urine which may have passed forwards from the perineum to the front of the abdomen, from extending downwards on to the thigh.

The muscles of the abdominal wall are divided into three groups:—

Anterior Group = Rectus abdominis and pyramidalis.

Lateral Group = External oblique, internal oblique, and transversalis abdominis.

Posterior Group = Psoas and quadratus lumborum.

In the anterior and posterior groups, the muscle fibres are arranged vertically; in the lateral group, the external oblique runs mainly downwards and inwards, the internal oblique upwards and inwards, whilst the transversalis is directed horizontally

The muscles of the abdominal wall fulfil several important functions—(*a*) by their contraction they raise the intra-abdominal tension, and are thus essential for such acts as forced expiration, vomiting, etc.; (*b*) they protect the delicate abdominal viscera; and (*c*) act as flexors of the pelvis and the spine.

Table of the Chief Attachments and Nerve Supply of the Muscles of the Abdominal Wall.

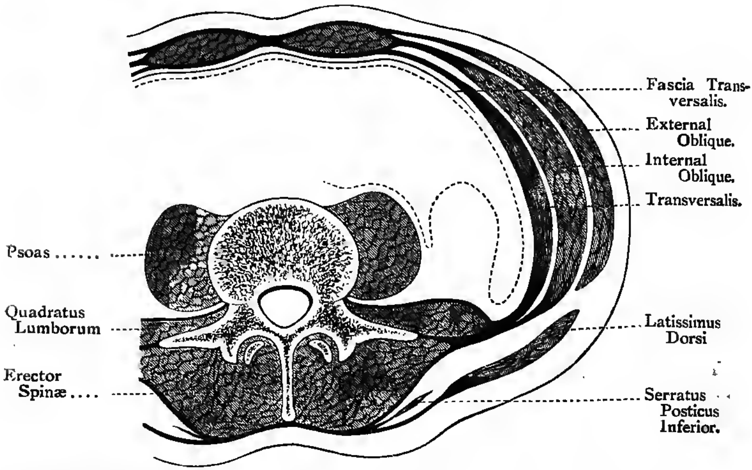
Muscle.	Origin.	Insertion.	Nerve Supply.
Quadratus lumborum	(a) Transverse processes of two lumbar vertebræ; (b) ilio-lumbar ligament; (c) posterior part of inner lip of iliac crest.	(a) Inner half of last rib; (b) transverse processes of upper lumbar vertebræ.	First, second, and third lumbars
Psoas magnus	(a) Intervertebral discs from last dorsal to fifth lumbar vertebræ; (b) fibrous arches over lumbar arteries; (c) transverse processes of lumbar vertebræ.	Blends with iliacus to form ilio-psoas which goes to lesser trochanter of femur.	Third lumbar.
Pyramidalis	Front of pubic crest.	Linea alba.	Last dorsal.

Muscle.	Origin.	Insertion.	Nerve Supply.
Rectus abdominis	Front of pubic crest and symphysis.	(a) Xiphoid process; (b) fifth, sixth, and seventh costal cartilages.	Lower six intercostals; last dorsal; ilio-inguinal; ilio-hypogastric.
External oblique	Lower eight ribs.	(a) Anterior third of outer lip of iliac crest; (b) linea alba; (c) inguinal ligament; (d) pubic crest of opposite side; (e) Gimbernat's (lacunar) ligament.	
Internal oblique	(a) Outer half of inguinal ligament; (b) anterior two-thirds of intermediate space of iliac crest.	(a) Lower four ribs; (b) linea alba; (c) conjoined tendon into ilio-pectineal line.	
Transversalis	(a) Outer third of inguinal ligament; (b) anterior half of inner lip of iliac crest; (c) lumbar fascia; (d) lower six ribs.	(a) Linea alba; (b) conjoined tendon into ilio-pectineal line.	

Sheath of the Rectus.—The sheath of the rectus is formed by the aponeurosis of the internal oblique splitting at the outer border of the rectus into two lamellæ, which, after embracing the muscle, unite again in the linea alba. The aponeurosis of the external oblique, as it passes inwards to the middle line, adheres to the anterior lamella, and in like manner the trans-

versalis muscle strengthens the posterior lamella. At the origin of the rectus there is no proper sheath, the muscle being covered in front by the aponeurosis of the external oblique, and supported posteriorly by the transversalis muscle. One-third of the distance between the umbilicus and the symphysis pubis, the posterior layer of the sheath often ceases abruptly;

Fig. 46.—The Sheath of the Rectus and Abdominal Wall. (After Cunningham.)



The dotted line represents the Peritoneum. The Fascia Transversalis is only figured in front

its free edge is crescentic, with the concavity directed downwards, and is called the semi-circular line (fold of Douglas). Accordingly, below this point, the rectus rests directly upon the fascia transversalis.

Enclosed within the sheath are the terminations of the lower six intercostal and the last thoracic nerves, the inferior (deep) and superior epigastric arteries, and the recti and pyramidales muscles.

Inferior Epigastric and Deep Circumflex Iliac Arteries.—These vessels are important as anastomosing channels after ligature of the common and external iliac arteries. Both arise from the external iliac, about a quarter of an inch above the inguinal (Poupart's) ligament, and both are accompanied by two venæ comites.

The inferior epigastric lies for the most part in the extra-peritoneal fat, clothed by the fascia transversalis; it pierces the latter, however, shortly before it enters the sheath of the rectus. At first directed inwards, it intervenes between the inguinal ligament and the abdominal inguinal ring, then turns upwards and

Fig. 47.—The Sheath of the Rectus below the Semi-Circular Fold. (After Cunningham.)

The dotted line represents the Peritoneum.

inwards immediately to the inner side of the ring forming the outer boundary of Hesselbach's triangle Here the vas deferens (or round ligament) and spermatic vessels hook round its outer side. The artery enters the sheath by passing in front of the semi-circular line, and ascends to anastomose with the superior epigastric branch of the internal mammary, and the lower intercostal arteries. The main branches of the inferior epigastric are: (*a*) external spermatic (cremasteric), which supplies the cremaster muscle; and (*b*) pubic, a small twig passing to the back of the pubes to anastomose with the pubic branch of the obturator. (*See* Abnormal Obturator.)

Kocher ligatures the deep epigastric by an incision

three fingers'-breadth above, and parallel with the inner half of the inguinal ligament.

The course and relations of the deep circumflex iliac must be carefully considered, as abscesses are frequently opened in its vicinity. From its origin, the artery runs outwards behind the inguinal ligament, embedded in the extra-peritoneal fat and resting upon the fascia iliaca. Opposite the anterior superior iliac spine the artery pierces the fascia transversalis, and turns along the inner aspect of the iliac crest, lying between the fascia transversalis and the transversalis muscle. About the middle of the crest it emerges through the transversalis, reaching the interval between this muscle and the internal oblique. Here the artery terminates by anastomosing with the ilio-lumbar. An ascending branch is given off at the level of the anterior superior spine to anastomose with the lumbar arteries.

In order to apply a ligature, an incision is made two inches long parallel with, and slightly above, the outer half of the inguinal ligament.

Abdominal Rings.—The term ring is somewhat of a misnomer, as in neither case are the margins of the opening circular.

The *subcutaneous inguinal ring* (*external abdominal*) is a deficiency in the aponeurosis of the external oblique muscle. It is triangular in shape, and is directed outwards and slightly upwards. The base is formed by the pubic crest ; the outer pillar or crus by the inguinal ligament, while that portion of the aponeurosis which is inserted into the symphysis and the pubic crest of the opposite side, serves as the inner pillar. The two pillars are retained in apposition by a series of transverse bands, the intercolumnar fibres, which are prolonged upon the spermatic cord as the intercolumnar fascia. A hernia passing through the subcutaneous inguinal ring receives

an investment from this fascia. When palpated by invaginating the scrotum, a normal ring only admits the tip of the index finger; on dissection, however, the dimensions are :—

Base to apex . . .	1 inch
Breadth of base . .	½ inch

As the spermatic cord or round ligament issues from the inguinal canal it rests upon the outer pillar.

In females the ring is much smaller than in males.

If the thigh be flexed, and then rotated inwards, the area of the ring is increased, and, accordingly, when the surgeon endeavours to reduce an inguinal hernia by taxis, he places the patient in this position.

The *abdominal inguinal ring* (*internal abdominal*) is an oval-shaped orifice in the fascia transversalis, through which the spermatic cord, or round ligament, enters the inguinal canal. Its long axis is placed vertically and is about half-an-inch in extent. The ring is situated half-an-inch above a point a little internal to the middle of the inguinal ligament. The margins of the opening are prolonged upon the cord as the infundibuliform fascia. It has already been mentioned how closely related are the inferior epigastric artery and the abdominal inguinal ring.

In old-standing cases of inguinal hernia the abdominal ring is frequently dragged downwards by the protrusion, and may assume a position immediately behind the subcutaneous ring.

Inguinal Canal.—This intermuscular space connecting the subcutaneous and abdominal rings has both an ante-natal and a post-natal importance. Before birth it serves for the transmission of the testicle; after birth it may allow of the passage of an inguinal hernia.

The length of the canal in the adult averages one and a half inches. It has an oblique direction running

downwards, inwards, and slightly forwards. In male subjects it contains the spermatic cord, on which very frequently a fibrous strand, the remains of the processus vaginalis, may be detected. In females the round ligament of the uterus replaces the spermatic cord, and the processus vaginalis is occasionally represented by a small tubular diverticulum of peritoneum, known as the canal of Nuck.

Boundaries.—In front—The aponeurosis of the external oblique muscle covers the whole extent of the anterior wall, and is reinforced in the outer third of the canal by the internal oblique.

Behind—The conjoined tendon, the triangular fascia, and the fascia transversalis.

Above—The lower arched fibres of the internal oblique and transversalis abdominis muscles.

Below—The abdominal aspect of the inguinal and lacunar (Gimbernat's) ligaments.

The inguinal canal is not such a great source of weakness to the abdominal wall as might be expected, because (*a*) its direction is very oblique; (*b*) the fascia transversalis is stronger in this region than elsewhere; (*c*) the muscles forming the walls of the canal are so arranged that their contraction acts as an inguinal sphincter. (Moynihan.)

Spermatic Cord.—The spermatic cord possesses three fascial investments derived from certain of the structures forming the anterior abdominal wall. These are from without inwards: (*a*) the intercolumnar fascia from the subcutaneous inguinal ring; (*b*) the cremastric fascia, consisting of several muscular strands united by areolar tissue; (*c*) the infundibuliform fascia from the abdominal inguinal ring—*i.e.*, from the fascia transversalis. The cord is made up of:—

(i.) Nerves	External spermatic branch of genito-crural (genito-femoral) supplying the cremaster muscle. Sympathetic filaments.
(ii.) Arteries	Artery to the vas deferens—a branch of the superior vesical. Cremasteric (external spermatic)—from the inferior epigastric. (Internal) spermatic—from the abdominal aorta.
(iii.) Veins	Veins from the vas deferens—open into the superior vesical vein. Spermatic veins or pampiniform plexus—open on the right side into the inferior vena cava, a valve guarding the opening; on the left side they open at right angles into the left renal vein, no valve being interposed.

(iv.) Lymphatics from the testicle.

(v.) Vas deferens.

The *spermatic veins* arise under cover of the tunica-albuginea. Emerging from the testicle they travel upwards, as two or three trunks, lying in front of the vas and its vessels, and surrounding the internal spermatic artery. On each side these trunks unite to form a single vein, which crosses the psoas muscle and ureter, to terminate in the manner previously mentioned. On the right side the vein passes under cover of the ileum, and on the left beneath the iliac colon. During adolescence the veins are very liable to become varicose, especially the left spermatic. Several anatomical facts have been adduced in order to explain why a varicocele is so frequently leftsided. These are: (*a*) the mode of

termination of the left vein; (*b*) the greater length of the left veins; (*c*) the left veins receive tributaries from the iliac and pelvic colon, and, accordingly, when the portal circulation is stagnant these veins become engorged; and (*d*) in habitual constipation, the presence of fæcal masses in the iliac colon may retard the circulation in the left vein.

A suddenly occurring varicocele suggests an examination of the corresponding kidney, for in cases of renal sarcoma, a detached fragment of the tumour may wander off in the renal vein, and cause embolism of the spermatic vein.

The veins accompanying the vas carry on the spermatic circulation after excision of the pampiniform plexus for varicocele, thus preventing testicular atrophy.

Hesselbach's Triangle.—This triangular area is included between the inferior epigastric artery and the outer border of the rectus abdominis muscle. Its base is formed by the inner half of the inguinal ligament. The triangle is subdivided into two unequal portions by the obliterated hypogastric artery, the inner half usually being the bigger. The floor of the inner portion is the conjoined tendon, whilst the fascia transversalis forms the floor of the outer half.

Fascia Transversalis. — The fascia transversalis lines the whole of the visceral aspect of the anterior abdominal wall, intervening between the deep surface of the transversalis muscle and the extra-peritoneal fat.

After clothing the psoas, the fascia becomes adherent to the inner lip of the iliac crest, and joins the iliac fascia, while below, the fascia transversalis has several important attachments: (*a*) *external to the femoral vessels*, the fascia is fixed to the inguinal ligament, again becoming continuous with the iliac fascia; (*b*) *opposite the femoral vessels*, the fascia passes beneath the

inguinal ligament forming the anterior layer of the femoral sheath; and (*c*) *internal to the femoral vessels*, it is attached to the ilio-pectineal line immediately behind the conjoined tendon.

Descent of the Testicle.*—Until the sixth month of fœtal life the testes lie on the posterior wall of the abdominal cavity below the developing kidney. They are covered by germ epithelium. Fixed to the junction of the vas deferens with the globus minor of the epididymis is a band of unstriped muscle, the gubernaculum testis. It acts as a rudder in guiding the testis through the inguinal canal into the scrotum.

As the gubernaculum burrows through the anterior abdominal wall to reach the scrotum, it carries a peritoneal diverticulum—the processus vaginalis, *into* which the testicle subsequently descends. Owing partly to the involution of the gubernaculum, and partly to the growth of the inguinal canal, the testicle passes through the abdominal ring, traverses the canal, emerges through the subcutaneous ring, and finally reaches the bottom of the scrotum by the middle of the ninth month.

The lower attachments of the gubernaculum are very numerous, the chief being (*a*) the scrotum; (*b*) the inguinal musculature; (*c*) the anterior aspect of the os pubis; (*d*) the region of the saphenous opening; and (*e*) the perineum.

The testicle may fail to descend, or may remain stranded in the inguinal canal—retained or undescended testicle. *Ectopia testis* results if either the pubic, saphenous, or perineal fasciculi are stronger than the

* Dr Berry Hart has shown that our previous conceptions of the mechanism and nature of testicular descent were inaccurate in many important particulars. For a full account of this interesting process, the reader is referred to Dr Hart's published papers.

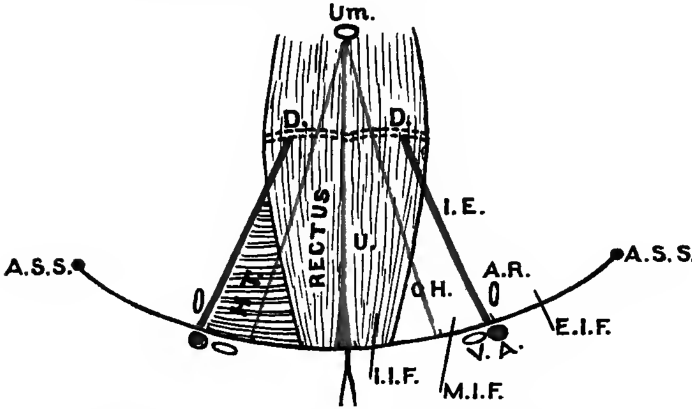
scrotal. It is extremely doubtful if complete spermatogenesis occurs, unless the testicle descends into the scrotum.

At birth the processus vaginalis commences to atrophy both at the abdominal ring and at the summit of the testicle; the portion below the latter point remaining patent as the tunica vaginalis. The part of the processus vaginalis intervening between the abdominal ring and the top of the testicle, is called the funicular process. It is obliterated a little after birth; if not, it may become cystic—encysted hydrocele of the cord. Hernia into the funicular process is the commoner form of inguinal hernia.

Inguinal Hernia.—An inspection of the lower part of the posterior surface of the anterior abdominal wall will reveal five peritoneal ridges, one mesial, and two lateral on each side. The mesial fold is formed by the urachus passing from the summit of the bladder to the umbilicus; it is the atrophied remnant of the intra-abdominal portion of the allantois. Flanking it are two elevations due to the obliterated hypogastric arteries; they also are directed towards the umbilicus. External to these, notice the ridges caused by the inferior epigastric arteries. Between the above peritoneal elevations are the inguinal fossæ. The external fossa lies to the outer side of the inferior epigastric artery, and presents a dimple indicating the position of the abdominal ring; it is through this area that an oblique inguinal hernia passes. The middle fossa is between the inferior epigastric and the obliterated hypogastric, while the internal fossa is bounded by the obliterated hypogastric and the urachus. A direct hernia (hernia through the linea semilunaris) usually escapes through the internal fossa, which superficially corresponds to the subcutaneous inguinal ring.

An oblique hernia may remain stationary in the inguinal canal, a bubonocele, or become complete by leaving the canal through the subcutaneous ring to reach the scrotum or labium. When complete the coverings are: (*a*) integument; (*b*) superficial fascia; (*c*) intercolumnar fascia; (*d*) cremasteric fascia; (*e*) infundibuliform fascia; (*f*) sub-peritoneal fat; and (*g*) parietal peritoneum, forming the sac.

Fig. 48.—DIAGRAM OF THE INGUINAL FOSSÆ.



A.R. Deep Abdominal Ring.
A.S.S. Anterior Superior Spine.
E.I.F., M.I.F., I.I.F. Inguinal Fossæ.
H.T. Hesselbach's Triangle.
O. Semicircular Line.
O.H. Obliterated Hypogastric.
U. Urachus.
V.A. Femoral Vessels.
I.E. Inferior Epigastric.

A direct protrusion (hernia through the linea semilunaris) is much rarer. The neck of the sac emerges to the inner side of the inferior epigastric, between this vessel and the outer border of the rectus muscle—*i.e.* through Hesselbach's triangle. The fascia traversalis is carried forwards to form a covering, and also in the great majority of cases the conjoined tendon. This form of hernia does not usually become complete. As the bladder is sometimes adherent to the sac, great care must be

exercised during a radical operation. The coverings of a direct hernia are: (*a*) integument; (*b*) superficial fascia; (*c*) intercolumnar fascia; (*d*) conjoined tendon; (*e*) fascia transversalis; (*f*) sub-peritoneal fat; and (*g*) parietal peritoneum.

In a strangulated inguinal hernia the constricting bands around the neck of the sac have to be divided. In such cases the edge of the knife must always be directed *away* from the inferior epigastric artery; therefore in oblique hernia cut upwards and outwards, and in direct hernia, upwards and inwards.

Usually an oblique hernia is associated with imperfect closure of the processus vaginalis. When the process remains patent throughout its whole length, a *congenital* hernia or hydrocele may result; it will lie anterior to the testicle. If the process is shut off below but open above, *funicular* hernia results; this variety does not descend below the summit of the testis. Rarely, an upward diverticulum from the tunica vaginalis extends in front of the hernia, and the surgeon has to cut through three layers of peritoneum before the hernial contents are encountered—the term *infantile* is applied to this form. *Encysted* hernia is produced when the processus vaginalis is obliterated above but patent below; the hernia invaginates the open process.

Owing to the narrowness of the inguinal canal, hernia is not common in females in this region. When it does occur it is of the congenital variety, the protrusion descending into a patent canal of Nuck. The ovary is frequently found as a content of the sac.

Cutaneous Nerves.—The cutaneous nerves of the anterior abdominal wall comprise the anterior divisions of the lateral branches of the lower six intercostals; the anterior cutaneous branches of these nerves; the twelfth dorsal, and the hypogastric branch of the

ilio-hypogastric. After leaving the intercostal spaces, the lower six intercostal nerves pass forwards in the interval between the transversalis and the internal oblique muscles as far as the outer border of the rectus. Here they enter the sheath, and after supplying the rectus, emerge through the anterior layer to become the anterior cutaneous nerves. The last dorsal and the ilio-hypogastric send their lateral cutaneous branches to the buttock: the remaining portions of the nerves follow a similar course to that of the lower intercostals.

The nerves of the anterior abdominal wall are placed at fairly equal distances apart, and run almost horizontally. Remember that the sixth lies opposite the xiphoid process; the seventh, eighth, and ninth between this process and the umbilicus; the tenth at the level of the umbilicus, and the eleventh, twelfth, and the first lumbar between the umbilicus and the symphysis.

The skin of the abdominal wall, the muscles, and the parietal peritoneum are innervated by the same spinal segments. Accordingly, any stimulus applied to the terminations of these cutaneous nerves is instantly followed by contraction of the associated muscles. The nerves supplying the abdominal wall communicate with the sympathetic ganglia from which the splanchnics arise, and as the splanchnics are distributed to the abdominal viscera, injury to the viscera results in "boarding" of the abdominal wall.

Lymphatics.—The lymphatics are divided into two sets, superficial and deep. The former, above the umbilicus, drain into the axillary glands; below the umbilicus, into the inguinal nodes. Above the umbilicus, the deep set accompany the superior epigastric artery to the sternal glands; below, they pass with the inferior epigastric to the iliac glands.

ABDOMINAL CAVITY.

The abdomen proper is separated from the pelvic cavity by an imaginary plane passing through the brim of the pelvis. In the erect position the plane of the brim makes an angle of 60° with the horizon (Naegele). As the area of the abdominal cavity is so great, it is necessary for descriptive purposes to subdivide it. We shall here adopt the method advocated by Addison.

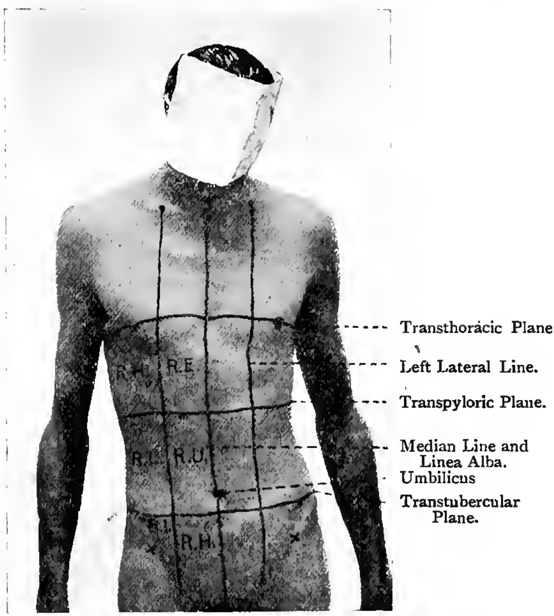
The *lateral lines* are drawn through a point midway between the anterior superior iliac spine and the symphysis pubis, while the *median line* connects the suprasternal notch and the symphysis pubis. The level of the *transpyloric line* "may be determined with convenience and sufficient accuracy by taking a point on the surface of the front of the body, half-way between the umbilicus and the notch at the lower border of the body of the sternum" (Addison). A plane passing through this line cuts—(*a*) the hilum of each kidney; (*b*) the pylorus; (*c*) the apex of the duodeno-jejunal flexure; (*d*) the lower border of the body of the pancreas; and (*e*) the body of the first lumbar vertebra. The *transtubercular line* is drawn through a point midway between the transpyloric line and the symphysis pubis; it usually passes through the tubercles on the iliac crests, and corresponds to the fifth lumbar vertebra.

By means of the above lines twelve regions are mapped out; they are named the right and left hypochondrium, epigastrium, lumbar, umbilical, inguinal, and hypogastrium (Fig. 49).

The Peritoneum.—The peritoneum in male subjects forms an entirely closed sac, in females it communicates with the Fallopian tube, and therefore with the exterior. The latter fact accounts for the frequency with which

tubal septic mischief extends to the peritoneal cavity. Two layers are found, parietal and visceral; the former is sensitive, while the latter is stated to be insensitive. In addition to more or less clothing the abdominal

Fig. 49.—ADDISON'S METHOD OF ABDOMINAL TOPOGRAPHY.



R.H. Right Hypochondrial Region.
R.L. Right Lumbar Region.
R.I. Right Inguinal Region.
R.E. Rigbt Epigastric Region.
R.U. Right Umbilical Region.
R.H. Right Hypogastric Region.
X.X. The Anterior Superior Iliac Spines.

contents, the visceral layer provides folds uniting them to the parietes.

From a clinical standpoint, the peritoneum demands careful attention because of (*a*) its high absorptive power; (*b*) the readiness with which it reacts to an

injury, either traumatic or bacterial; and (*c*) its numerous ramifications, the inter-visceral recesses lodging any pathological secretions present in the cavity. It is very important to remember that the absorptive power of the peritoneum decreases as we pass from the upper part of the abdomen towards the pelvis, and hence the advantage of Fowler's position.

Anatomically, the peritoneal cavity consists of two sacs, greater and lesser, the latter being a diverticulum arising from the former. The aperture by which the sacs communicate is termed the foramen of Winslow (epiploicum), and during health its margins are in apposition. The foramen normally admits two fingers, and has very important boundaries. They are—

Anterior—The right free margin of the gastro-hepatic omentum and its contents, namely, the portal vein, hepatic artery, common bile duct, and the hepatic nerves. Remember that the duct is on the right, the artery on the left, and the portal vein behind and between the duct and the artery.

Behind—The right crus of the diaphragm and the inferior vena cava.

Above—The caudate lobe of the liver.

Below—The first part of the duodenum and the hepatic artery.

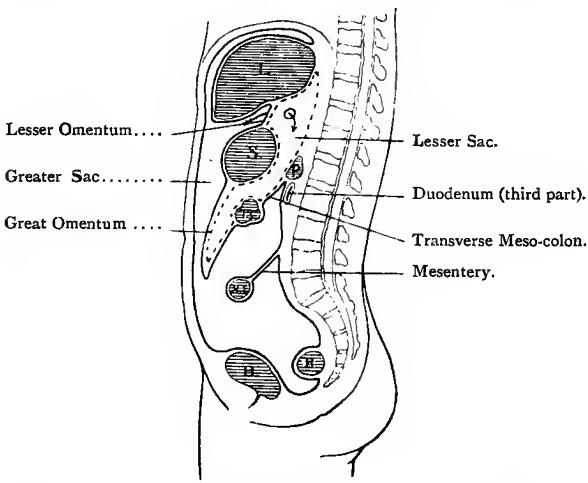
Two additional ways of reaching the lesser sac may be mentioned, either by dividing the anterior layers of the great omentum, or by lifting up the great omentum, and incising the transverse meso-colon (Fig. 50).

Peritoneal folds are of three varieties—omenta, mesenteries, and ligaments.

Omenta.—These are double layers of peritoneum connecting the stomach to any other viscus. They are three in number: (*a*) the great, or gastrocolic, omentum is an apron-like fold suspended from the greater curva-

ture of the stomach, and hanging over the transverse colon ; (*b*) the lesser, or gastro-hepatic, omentum stretches from the lesser curvature of the stomach to the transverse fissure of the liver, bridging over the foramen of Winslow ; while (*c*) the least, or gastro-splenic, omentum passes from the gastric fundus to the hilum of the spleen.

Fig. 50.—Vertical Section of Peritoneum (Diagrammatic).



L. Liver. T.C. Transverse Colon. R. Rectum.
S. Stomace. S.I. Small Intestine. P. Pancreas.
B. Bladder.

The arrow indicates the position of the foramen of Winslow (epiploic foramen).

Mesenteries are double layers of peritoneum fixing any part of the alimentary canal to the posterior wall of the abdominal cavity. The constant mesenteries are the enteric, transverse meso-colon, meso-appendix, and pelvic meso-colon.

Ligaments.—This term is applied to a double layer of peritoneum connecting viscera either to the diaphragm

or to the anterior abdominal or pelvic walls. The chief ligaments are: lieno-renal, phrenico-colic, gastro-phrenic, ligaments of the liver, false ligaments of the bladder, and several ligaments of the uterus.

Peritoneal Fossæ.—These fossæ are of surgical interest, as they are sometimes the sites of internal herniæ.

Duodenal—Several recesses may occur in the vicinity of the terminal portion of the duodenum and the duodeno-jejunal flexure. The common ones are—(*a*) superior duodenal—the mouth of this fossa is directed downwards, and the inferior mesenteric vein lies on the left side; (*b*) inferior duodenal—the orifice points upwards, and both the inferior mesenteric vein and the ascending branch of the colica sinistra artery pass along the left border; (*c*) paraduodenal—this depression will be found a little to the left of the previous two fossæ, and has the same relations as the inferior fossa.

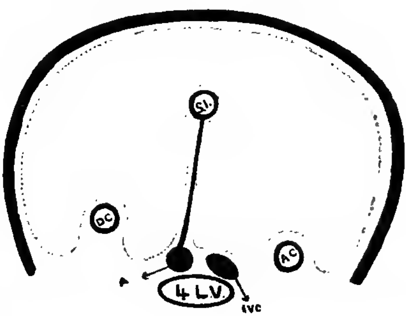
Intersigmoid—This fossa is rarely of sufficient size to be a source of danger in the adult. It is found beneath the pelvic meso-colon, and is directed upwards.

In the Region of the Cæcum—The more constant fossæ are (*a*) retro-cæcal or retro-colic; (*b*) ileo-cæcal; and (*c*) ileo-colic. The ileo-cæcal is found in the recess between the lower border of the ileum and the cæcum; it is bounded in front by the ileo-cæcal fold ("the bloodless fold of Treves"), and behind by the meso-appendix. On the other hand, the ileo-colic will be observed in the angle between the upper border of the ileum and the commencement of the ascending colon, limited anteriorly by the ileo-colic fold (containing the anterior cæcal branch of the ileo colic artery), and posteriorly by the enteric mesentery. The orifice in the case of the retro-cæcal fossa points downwards, while in the ileo-cæcal and ileo-colic it is directed towards the left.

It is important to remember that the greater part of the vermiform appendix may be lodged within one of the cæcal fossæ.

The Enteric Mesentery.—This is fixed in an oblique manner to the posterior wall of the abdominal cavity, from the left side of the body of the second lumbar vertebra to the right iliac fossa. Accordingly, right-sided collections of fluid tend to gravitate towards the right iliac fossa, while collections to the left of the mesentery drain into the pelvis. The root of the

Fig. 51.—Peritoneum at Level of Fourth Lumbar Vertebra.



S.I. Small Intestine. A.C. Ascending Colon.
D.C. Descending Colon. I.V.C. Inferior Vena Cava.
A. Aorta giving off the Superior Mesenterea.

mesentery and the duodeno-jejunal flexure are attached to the diaphragm (on the right side of the œsophageal orifice) by a band of unstriped muscle, the suspensory muscle of Treitz.

Between the two layers of the mesentery are (*a*) a certain amount of adipose tissue; (*b*) the vasa intestini tenuis branches of the superior mesenteric vessels; (*c*) branches from the superior mesenteric plexus of nerves; (*d*) lymphatic glands and lacteals; and (*e*) the small intestine.

THE HEPATIC SYSTEM.

Liver.—The greater part of this organ occupies the right hypochondrium. In addition, it is found in the right and left epigastrium, the right lumbar and the right umbilical regions, and a small portion in the left hypochondrium.

The following are the average dimensions of the liver in adult males:—

Antero-posterior	= 6 inches.
Vertical	= 6-7 inches.
Transverse	= 7 inches.
Weight	= 3-3¼ pounds.

During expiration its upper limit reaches, on the right side, the upper border of the fifth rib, whereas on the left side, it only reaches the lower border of the corresponding rib. When the recumbent posture is assumed the liver ascends about an inch.

The potential space between the upper surface of the liver and the diaphragm is termed the sub-phrenic space; it is subdivided into two portions by the falciform ligament. Fluid may collect in the right sub-phrenic compartment from suppuration in the liver and biliary passages, the perforation of a duodenal ulcer, appendiceal abscess, empyema, or suppurative lesions of the right kidney. Accumulations of fluid in the left compartment result from the perforation of a gastric ulcer, abscesses of the spleen, empyema, and suppurative conditions of the left kidney.

The non-peritoneal areas of the liver are—(*a*) that part of the posterior surface between the layers of the coronary ligament, the "bare area"; (*b*) between the gall-bladder and its impression on the inferior hepatic surface (usually non-peritoneal); and (*c*) the narrow tract between the layers of the falciform ligament.

Surfaces and Relations—Five surfaces are usually described—superior, inferior, anterior, posterior, and right lateral. The *superior* is closely applied to the diaphragm, and presents an impression for the heart and pericardium; the *anterior* is in relation to the diaphragm and a small portion of the anterior abdominal wall; the *right lateral* touches the diaphragm from the seventh to the eleventh ribs. On the *posterior* surface the left lobe is indented by the œsophagus; the Spigelian lobe is clothed by the lesser sac of peritoneum; and the right lobe is in relation to the inferior vena cava, the diaphragm, and the right suprarenal capsule. The *inferior* surface must be carefully studied. First note the transverse fissure, or hilum of the organ; the hepatic artery lies on the left side, the biliary ducts on the right, and the portal vein in the middle, but on a deeper plane. The viscera in relation to this surface are—the cardiac portion of the stomach to the left lobe; the pylorus, or the beginning of the duodenum to the quadrate lobe; the first part of the duodenum to the caudate lobe; and the hepatic flexure of the colon, and the right kidney to the right lobe.

Riedel's lobe is a tongue-like process often present, which descends from the anterior sharp margin of the liver immediately external to the gall-bladder. It has been mistaken for a tumour, and for a distended gall-bladder. The anterior margin has a notch—the umbilical notch for the ligamentum teres; it is found from one to one-and-a-half inches to the right of the middle line.

Glisson's capsule surrounds the organ, and entering the hilum, accompanies the ramifications of the portal vein, hepatic artery, and bile-ducts.

Gall-Bladder and Bile-Ducts—The gall-bladder is a pear-shaped viscus lying on the under surface of the

liver. It consists of a fundus, a body, and a neck. Note that the fundus is represented on the surface of the abdomen by a point midway between the ninth right costal cartilage and the outer border of the rectus. The neck is somewhat S-shaped, and terminates by becoming the cystic duct. In size, a normal adult bladder is 3 inches long and 1¼ inches wide, while its average capacity is 1 to 1½ ounces. The relations of the viscus are: *above*, the liver, on the *left* the pylorus, to the *right* the hepatic flexure of the colon; *below* the transverse colon, and the first part of the duodenum. It is nourished by the cystic artery, a branch of the right hepatic. On reaching the neck, the artery divides into an internal and an external branch; they run on each side of the viscus as far as the fundus. The cystic vein opens into the portal vein. The mucous membrane has a honey-comb appearance, and is plentifully supplied with glands, which secrete a translucent mucinoid substance.

Ducts—*Common Hepatic*

	Length .	=	1–1¼ inches.
	Diameter .	=	¼ inch.
Cystic			
	Length .	=	1½ inches.
	Diameter .	=	⅛ inch.
Common			
	Length .	=	3¼ inches.
	Diameter .	=	¼ inch.
Ampulla of Vater			
	Length .	=	¾ inch.

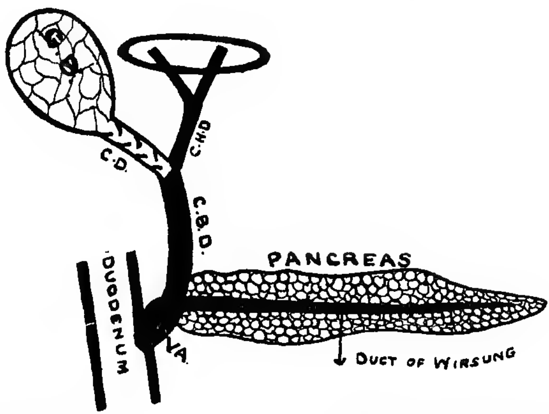
The duodenal orifice is only 2.5 mm. in diameter (Opie).

The right and left hepatic ducts unite as the common hepatic duct, which in turn is joined by the cystic duct to form the common bile duct. Slit up the

cystic duct, and notice the ridges projecting from its mucous surface, the valves of Heister. Owing to these valves, it is very difficult to pass a probe from the gall-bladder along the duct.

The common bile duct is divided into four parts (*a*) supra-duodenal; (*b*) retro-duodenal; (*c*) pancreatic; and (*d*) interstitial. It runs along the right free margin of the gastro-hepatic omentum, in front of the foramen of

Fig. 52—Diagram of Biliary Ducts.



G.B. Gall Bladder.
C.D. Cystic Duct opened to show Valves of Heister.
C.H.D. Common Hepatic Duct.
C.B.D. Common Bile Duct.
V.A. Ampulla of Vater.

Winslow, with the portal vein and the hepatic artery on its left. It descends behind the first part of the duodenum; then behind the head of the pancreas, having the superior mesenteric vein on its left side, and being surrounded by pancreatic tissue in 68% of cases (Robson and Cammidge). Next it passes along the internal border of the second part of the duodenum, being crossed by the superior pancreatico-duodenal

artery. The duct then unites with the duct of Wirsüng from the pancreas, to form the ampulla of Vater, and opens on the summit of the bile papilla in the second part of the duodenum. The ampulla is surrounded by a thin layer of unstriped muscle—Oddi's sphincter. Protecting the bile papilla is a small hood-like valvula connivens. Accompanying the common duct are several lymphatic nodes, two of which are fairly constant in position, one at the junction of the common hepatic duct with the cystic duct, and the other near the ampulla. When enlarged these glands have been mistaken for biliary calculi.

The gall bladder and bile ducts are lined by columnar epithelium.

When long obstructed, the common bile duct can stretch enormously; in many cases it has been found to have the diameter of the small intestine of an adult. (Treves and Hutchinson).

Lymphatics—Two sets of lymphatic glands are found in connection with the liver—a group in the transverse fissure, and a set in the gastro-hepatic omentum. The efferents from both groups terminate in the cœliac glands. The vessels of the liver are divided into superficial and deep. The latter drain into the nodes of the transverse fissure, and some accompany the inferior vena cava to the diaphragmatic glands. On tracing the superficial vessels we find they end in (*a*) the glands of the transverse fissure; (*b*) the diaphragmatic glands *via* the inferior vena cava lymphatics; (*c*) the coronary glands; (*d*) the cœliac nodes; and (*e*) through the diaphragm, and along the left internal mammary artery to the left supraclavicular glands.

THE PANCREAS.

The pancreas is an elongated gland, devoid of a distinct capsule, which stretches transversely across the visceral surface of the posterior abdominal wall from the duodenal concavity to the gastric area of the spleen.

It occupies the following regions:—the right epigastrium, left epigastrium, left hypochondrium, and right umbilical, and is described as consisting of a head, neck, body, and tail. The body lies opposite the first lumbar vertebra, the head reaching as low as the upper part of the third lumbar.

The gland averages 5½ inches (14 cms.) in length, and weighs 2¼-3½ ounces (66-102 grammes).

Two ducts are found: the main one, the duct of Wirsüng, joins the common bile duct at the ampulla of Vater, while the accessary duct (Santorini) opens into the duodenum about three quarters of an inch above the bile papilla. The orifice of the accessory duct is so narrow that the duct possesses an embryological rather than a physiological significance. Recent research has shown that the accessory duct is constantly present.

Relations—Only the chief relations will be mentioned:—

Head—Anterior—Transverse colon, origin of the portal vein, and the superior mesenteric vessels.

Posterior—Inferior vena cava, aorta, and the common bile duct.

This portion of the gland wanders over the second and third parts of the duodenum for a variable distance.

Neck—Anterior—Lesser sac of the peritoneum and the pylorus.

Posterior—Termination of the superior mesenteric, and the commencement of the portal vein.

The posterior aspect of the neck is separated from the head by a well-marked notch—the incisura pancreatis; it is occupied by the superior mesenteric vessels.

Body—Superior—Lesser sac of the peritoneum, the postero-inferior surface of the stomach, and the splenic artery winding along the upper border of the body.

Posterior—Aorta and the origin of the superior mesenteric artery, splenic vein, left suprarenal capsule, and the left kidney.

Inferior—Posterior layer of the transverse meso-colon, duodeno-jejunal flexure, coils of small intestine, and a part of the transverse colon.

Notice that the body is especially thick where it crosses over the left kidney.

Tail—Gastric surface of the spleen.

Cysts occasionally arise in the pancreas; they may bc either cyst-adenomata or true retention cysts. The commonest situation for the swelling to project is between the stomach and the transverse colon, or between the stomach and the liver. In the latter case the structures in the gastro-hepatic omentum lie in front of the tumour. Cancer of the head of the pancreas causes gradual obstruction of the common bile duct, the portal vein, and the inferior vena cava.

Blood Vessels and Lymphatics—The arterial supply is derived from—(*a*) the superior pancreatico-duodenal, a branch of the gastro-duodenal; (*b*) the inferior pancreatico-duodenal from the superior mesenteric; and (*c*) several twigs from the splenic. The superior pancreatico-duodenal runs in front of the head of the gland, while the inferior pancreatico-duodenal courses over the back

of the head, the two vessels anastomosing along the inferior margin of the head. On tracing the *lymphatics*, it will be found that they terminate in the following nodes:—left gastric (coronary), subpyloric, mesenteric, and suprapancreatic (pancreatico-splenic).

There is a free communication between the lymphatics of the pancreas and those of the gall bladder and bile ducts. This explains why chronic pancreatitis is often a sequel of cholecystitis and cholangitis.

THE SPLEEN.

This ductless gland is chiefly found in the left hypochondrium and the left epigastrium; the basal surface, however, projects below the transpyloric plane, and so occupies the upper part of the left lumbar region. The long axis of the organ is almost vertical in the erect position of the body, but when the patient is reclining, it practically coincides with that of the tenth rib. In adults the average dimensions are:—

Length	=	5 inches (12.5 cms.)
Breadth	=	3 inches (7.5 cms.)
Weight	=	6 ounces (170 gms.)

Its shape is mainly determined by the condition of the stomach and splenic flexure of the colon; only when the former is empty and the latter distended, is the irregular tetrahedron form produced. The anterior border usually presents two or three easily recognised notches.

The spleen is completely surrounded by peritoneum, and is fixed to adjacent viscera by two folds, the gastro-splenic omentum (ligament) containing the vasa brevia vessels, and the lieno-renal ligament conveying the splenic artery and vein. The splenic vessels are frequently adherent to the tail of the pancreas.

Relations—The *diaphragmatic surface* is in relation with that muscle, and the ninth, tenth, and eleventh ribs. In contact with the *renal surface* is the left kidney, while the stomach and the tail of the pancreas impress the *gastric surface.* The *basal surface* rests upon the splenic flexure of the colon, and the phrenico-colic ligament. Note that the hilum is found on the gastric surface.

Blood Vessels and Lymphatics—The splenic artery arises from the cœliac axis, and passes behind the lesser peritoneal sac (omental bursa), along the upper margin of the body of the pancreas, and in front of the left suprarenal and kidney to reach the splenic hilum. In the latter part of its course it lies in the lieno-renal ligament. Before entering the spleen it divides into four or five branches. The issuing veins unite as a single trunk which joins with the superior mesenteric to form the vena portæ.

No lymphatics are found in the splenic substance. The vessels from the capsule and trabeculæ terminate in the glands near the hilum, and in the suprapancreatic (pancreatico-splenic) nodes.

THE STOMACH.

The position and shape of the stomach vary within wide limits in each individual. The factors affecting them are—(*a*) the posture of the body, erect or reclining; (*b*) the amount of the contents of the stomach; (*c*) the stage of gastric digestion reached; (*d*) the degree of contraction of the abdominal muscles; and (*e*) the condition of the neighbouring viscera, especially the transverse colon and the liver. X-ray examinations following upon the administration of a "bismuth-meal" have considerably altered our conceptions regarding this viscus. It must be remembered, however, that the

flaccid pyriform sac seen in the dissecting rooms closely resembles the appearance of the organ when viewed during an operation.

The cadaveric stomach occupies the left hypochondrium, left epigastrium, and the left umbilical regions; in addition, the pylorus encroaches upon the right epigastrium and the right umbilical regions. The long axis of the organ is oblique, being directed from the fundus downwards, forwards, and to the right. regarding the surface topography, the following points should be found :—

Cardiac orifice—opposite the seventh left costal cartilage, one inch from the middle line.

Fundus—reaches the fifth rib in the left lateral or mid-clavicular line.

Pyloric Orifice—on the transpyloric line, half an inch to the right of the middle line.

Greater curvature—passes over the ninth left costal cartilage to cross the middle line two inches above the umbilicus.

According to the observations of Paterson, four parts can generally be distinguished—(*a*) cardia with fundus, (*b*) pyloric vestibule, (*c*) pyloric antrum, and (*d*) pyloric canal (see fig. 53). The fundus is dome-shaped, and during life probably always contains gas. It lies above a transverse line passing through the œsophageal orifice, being separated from the œsophagus by the *incisura cardiaca.* The pyloric vestibule may be present as a definite hour-glass constriction, or its position merely indicated by a shallow notch near the middle of the greater curvature. A well-marked sulcus, the *incisura angularis*, on the lesser curvature, indicates the commencement of the pyloric antrum, a bulging of the anterior gastric wall. It is separated from the cylindrical pyloric canal by a notch upon the greater curvature

called the *sulcus intermedius*. The pylorific orifice, guarded by the pyloric sphincter, projects into the duodenum; it is directed backwards and slightly towards the right. The pyloro-duodenal junction is represented by a constriction. When seen with the gastroscope the gastric mucosa has a dark-red, velvety appearance.

Both the dimensions and the capacity of the stomach vary widely, even in normal healthy individuals. The following figures represent an average-sized stomach, as found in the adult cadaver:—

Capacity = $2\frac{1}{2} - 2\frac{3}{4}$ pints (1200 - 1320 cc.s.).
Maximum length = 10 inches (25 cms.).
Maximum breadth = $4\frac{1}{2}$ inches (11.25 cms.).
Maximum depth (*i.e.*, antero-posterior measurement) = $3\frac{1}{2}$ inches (8.75 cms.).

Relations and Peritoneal Connections.—

Anterior Surface—The greater sac of peritoneum separating the stomach from the left lobe of the liver; the diaphragm, and the anterior abdominal wall.

When the stomach is empty, the transverse colon passes upwards and comes to lie in front of the contracted viscus.

Posterior Surface—The lesser sac (omental bursa) intervening between the stomach and the stomach bed; the latter being formed by (*a*) the upper surface of the pancreas ; (*b*) left suprarenal capsule; (*c*) upper part of the left kidney; (*d*) left crus of the diaphragm; and (*e*) transverse colon and transverse meso-colon.

In performing gastro-enterostomy by the posterior method, the surgeon makes an incision in the transverse meso-colon, and unites the commencement of the jejunum to the posterior gastric wall.

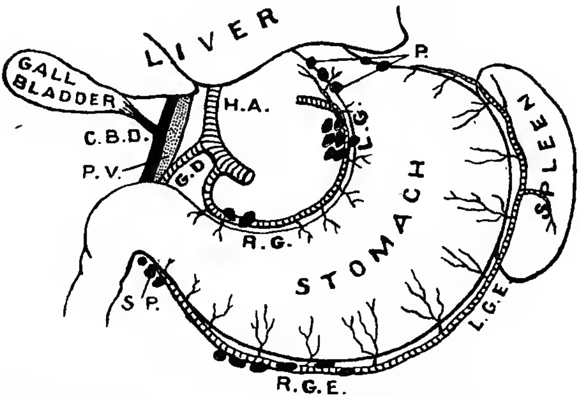
Lesser Curvature—Attached to the curvature is the

gastro-hepatic omentum with the coronary (left gastric) and pyloric (right gastric) vessels.

Greater Curvature—From this portion of the stomach, the gastro-colic omentum hangs downwards, as a large apron-like fold, containing the right and left gastro-epiploic vessels.

Fundus—The gastro-splenic omentum (ligament)

Fig. 53.—Blood-vessels and Lymphatic Glands of the Stomach.



C.B.D. Common Bile Duct.
G.D. Gastro-duodenal Artery.
H.A. Hepatic Artery.
L.G. Left Gastric Artery and Glands.
L.G.E. Left Gastro-epiploic Artery.
P. Paracardial Glands.
P.V. Portal Vein.
R.G. Right Gastric Artery and Glands.
R.G.E. Right Gastro-epiploic Artery and Glands.
S.P. Sub-pyloric Glands.

unites the fundus to the hilum of the spleen, and transmits the vasa brevia vessels.

Pylorus—The pyloric canal is one inch long. It rests upon the neck of the pancreas, and is related anteriorly to the quadrate lobe of the liver. To test the patency of the pyloric orifice, invaginate the anterior gastric wall with the index finger; a normal pylorus admits the tip of this digit.

Blood-vessels and Lymphatics.—Figure 53 illus-

trates the position of the gastric vessels and their relations to the lymphatic nodes. On the greater curvature are found two arteries, each accompanied by a vein, the gastro-epiploica sinistra and the gastro-epiploica dextra. Similarly there are two vessels on the lesser curvature, the coronary (left gastric) and the pyloric (right gastric). Connecting these two groups over the fundus are the vasa brevia vessels.

Mayo has called attention to two veins, superior and inferior, running over the anterior surface of the pylorus at the pyloro-duodenal junction. They lie almost in the same vertical plane.

Table of Gastric Arteries

Artery.	Source
Coronary (left gastric) .	Cœliac axis.
Pyloric (right gastric) .	Hepatic branch of cœliac axis.
Gastro-epiploica dextra .	Gastro-duodenal branch of hepatic.
Gastro-epiploica sinistra	Splenic branch of cœliac axis.
Vasa brevia . . .	Splenic branch of cœliac axis.

Table of Gastric Veins

Vein.	Termination.
Coronary (left gastric) .	Portal vein.
Pyloric (right gastric) .	Portal vein.
Gastro-epiploica dextra	Superior mesenteric vein.
Gastro-epiploica sinistra	Splenic vein.
Vasa brevia . . .	Splenic vein.
Superior vein of Mayo .	Pyloric vein.
Inferior vein of Mayo .	Gastro-epiploica dextra vein.

The stomach possesses three networks of lymphatic vessels: (*a*) submucous, (*b*) muscular, and (*c*) subserous;

they communicate with the vessels of the œsophagus and duodenum. Four groups of glands are present—(*a*) left gastric, along the left gastric blood vessels; (*b*) subpyloric, in the angle between the first and second parts of the duodenum; (*c*) right gastro-epiploic, in the great omentum; and (*d*) paracardial associated with the œsophageal orifice. An additional gland, the right gastric, is sometimes found in connection with the right gastric artery. All these glands ultimately drain into the nodes around the origin of the cœliac axis artery.

Nerve Supply.—The stomach derives its supply from two sources, the vagi and the semilunar (cœliac) sympathetic ganglia. The latter reach the stomach along the gastric arteries, while the vagi accompany the œsophagus, the left nerve ramifying upon the anterior surface of the viscus, and the right nerve upon the posterior surface.

THE INTESTINAL CANAL.

The duodenum is eleven inches long, and passes from the pylorus to the left side of the body of the second lumbar vertebra; the jejunum and ileum extend from this point to the right iliac fossa.

Duodenum.—*1st part or pars superior*—Reaches as far as the neck of the gall-bladder, and is two inches long. It is directed almost horizontally backwards.

Relations.—*Above*—Quadrate lobe of the liver and the foramen of Winslow (epiploic foramen).

Front—Gall-bladder.

Behind—Portal vein, gastro-duodenal artery, and the common bile duct.

Inner—Neck of the pancreas.

2nd part or *pars descendens*—runs from the neck of the gall-bladder to the lower border of

the third lumbar vertebra. It is three and a half to four inches long, and passes vertically downwards.

Relations—Front—Liver and the transverse colon.

Behind—Hilum of the right kidney with the renal vessels, and the inferior vena cava.

Outer—Hepatic flexure of the colon.

Inner—Head of the pancreas.

3rd part—or *pars inferior*—Extends to the duodeno-jejunal flexure on the left side of the body of the second lumbar vertebra. It is five inches long, and is first horizontal (pars horizontalis), then oblique (pars ascendens) in direction. When the pars horizontalis is absent the V-shaped duodenum results.

Relations—Above—Head and body of the pancreas.

Front—Uncinate process of the pancreas covered by the root of the mesentery with the superior mesenteric vessels; the stomach.

Behind—Inferior vena cava, aorta, left renal vein, and the left psoas muscle.

It is highly important to remember the peritoneal relations of the duodenum.

1st part—The first inch is completely surrounded by peritoneum, the remainder of the first part is non-peritoneal on its lower aspect.

2nd part—Left and posterior surfaces are non-peritoneal.

3rd part—Upper and posterior surfaces are non-peritoneal.

The peritoneum of the right side of the first part belongs to the greater sac, that of the left side to the lesser sac. Duodenal ulcers most frequently perforate through the right side of the first part, and thus infect the general peritoneal cavity.

The Jejuno-Ileum.—This portion of the intestinal canal is almost twenty-two feet in length, is freely movable, and decreases in size when traced downwards. It is customary to regard the upper two-fifths of this tube as jejunum, the rest being ileum. When healthy, it is possible to distinguish between the upper portions of the jejunum and the lower parts of the ileum; the jejunum is wider, darker, and feels thicker. In two per cent. of individuals, Meckel's diverticulum may be noticed arising from the ileum, about two and three-quarter feet above the ileo-cæcal valve. It is due to the non-obliteration of a portion of the vitelline duct, and usually causes no symptoms, but if it become adherent to one of the neighbouring coils of bowel, an internal hernia may result. The vascular supply of the jejuno-ileum is derived from the vasa intestini tenuis of the superior mesenteric artery. About twenty branches spring from the left or convex border of the superior mesenteric, which, after a variable distance, bifurcate, and then unite with each other to form a series of arterial arcades. From these latter fresh branches arise which in turn form secondary arcades. In the lower part of the ileum three or four arcades are present in the mesentery before the gut is reached, but the individual vessels are smaller than those found in the jejunum. The vasa recta arise from the terminal arcades, and pass alternately on each side of the wall of the bowel. Every branch of the superior mesenteric artery is accompanied by a single vein.

With regard to the mucous surface of the small

intestine note that—(*a*) the valvulæ conniventes commence in the duodenum about one inch from the pylorus, and gradually decreasing in size and number, disappear about the middle of the ileum; (*b*) Peyer's patches are mainly found in the lower ileum; (*c*) villi are present throughout the whole length of the small bowel.

The Large Intestine.—The diameter of the large intestine decreases as we pass towards the anus. On external examination it differs from the small intestine in the following respects:—(*a*) the calibre is greater; (*b*) the longitudinal muscular fibres are arranged in three distinct bands, the tænia coli, which produce a puckering of the large gut; (*c*) the presence of small peritoneal pouches containing fat, the appendices epiploicæ. Internally, Peyer's patches, villi, and valvulæ conniventes are absent.

Cæcum.—The cæcum occupies the right iliac fossa, lying immediately above the outer half of Poupart's (inguinal) ligament, and resting upon the ilio-psoas muscle. When distended, it is in contact with the great omentum and the anterior abdominal wall; when contracted, it is covered by a few coils of small intestine. It is the widest part of the intestinal canal, the average breadth being two and three-quarter inches; the length is two and a half inches. Normally the peritoneum entirely surrounds the viscus.

Developmentally, the cæcum first appears in the *left iliac fossa*, and by the rotation of the alimentary canal, which occurs during embryonic existence, the cæcum is carried to the *right hypochondrium*. From the latter region, it gradually descends to its permanent position in the *right iliac fossa*. Bear in mind, therefore, that the cæcum and appendix may be found in these abnormal sites.

The terminal portion of the ileum after passing upwards, backwards, and to the right, is projected slightly into the wall of the cæcum, forming the ileo-cæcal valve, of which the upper segment is horizontal and the lower segment oblique.

Vermiform Appendix.—Normally the appendix arises from the postero-internal aspect of the cæcum, this point being represented on the surface of the body, by the junction of the right and middle thirds of a line connecting the anterior superior iliac spines (Lanz). Its orifice is frequently guarded by a small fold—the valve of Gerlach. The apex of the appendix most commonly assumes one of three positions: (*a*) retro-cæcal; (*b*) pelvic, in females forming an anterior relation of the right ovary; (*c*) or retro-iliac, passing upwards and to the left behind the terminal position of the ileum. On an average the organ is three and a half inches long, and possesses a so-called mesentery (meso-enteriole), which does not, however, reach the apex. Between the two layers of the meso-enteriole are found the appendicular branch of the ileo-colic artery, the appendicular vein, and a little areolar tissue. Surgically, the readiest means of identifying the appendix is to find the cæcum, and trace its anterior longitudinal band downwards.

In young persons the sub-mucous coat of the appendix is exceedingly rich in lymphoid tissue.

Blood Supply of the Cæcum and Appendix.—Three branches from the ileo-colic artery (a branch of the superior mesenteric) supply this portion of the alimentary canal—the anterior cæcal, the posterior cæcal, and the appendicular. The anterior and posterior cæcals pass in front and behind respectively the ileo-cæcal junction, while the appendicular runs behind the ileum to ramify in the meso-enteriole a short distance away from its free margin.

Ascending Colon.—This portion of the large bowel is covered anteriorly and laterally by peritoneum; in exceptional cases an ascending meso-colon may be present. From below upwards the ascending colon rests upon the upper part of the iliacus, the quadratus lumborum, and the lower part of the right kidney. Two arteries supply it, the right colic and ileo-colic branches of the superior mesentric.

The Hepatic Flexure is directed forwards and to the left in the right hypochondrium. It is in relation to the right lobe of the liver, the gall-bladder, and the lower part of the right kidney.

Transverse Colon.—The transverse colon is the longest section of the large intestine (eighteen to twenty inches). It forms a loop, which projects forwards and downwards for a variable distance, the summit of the loop usually touching the anterior abdominal wall just above the umbilicus. Investing the bowel is the transverse meso-colon. The blood supply is derived from the middle colic branch of the superior mesenteric.

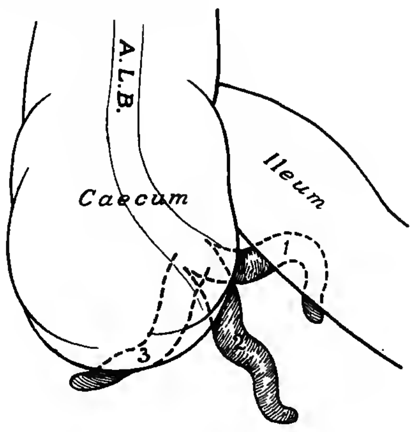
The Splenic Flexure is situated in the left hypochondrium. There it comes in contact with the tail of the pancreas, and the basal surface of the spleen. It reaches a higher level than the hepatic flexure, and lies more deeply in the abdominal cavity. A peritoneal band, the phrenico-colic ligament, passes from its left border to the diaphragm opposite the tenth rib.

Descending Colon.—About five inches long, the descending colon extends to the iliac crest, where it becomes continuous with the iliac colon. Its anterior surface is covered by some of the coils of the small intestines. Behind, we find the outer aspect of the left kidney, then the angle between the psoas and quadratus lumborum, and lastly, the latter muscle itself. The peritoneum clothes the anterior and lateral surfaces;

rarely a descending meso-colon is present. The arteries are the left colic and sigmoid branches of the inferior mesenteric.

Iliac Colon.—The iliac colon is five to six inches in length, and opposite the brim of the pelvis becomes the pelvic colon. In the great majority of cases no mesentery is found. The ilio-psoas muscle lies posterior, and,

Fig. 54.—Diagram of the Ileo-Cæcal Region to show the Various Positions which may be assumed by the Vermiform Appendix.



A.L B. Anterior tenia coli of Cæcum.
1. Iliac position.
2. Pelvic position.
3. Retro-cæcal position.

generally, the small intestine anterior to it. A distended iliac colon, however, is in contact with the anterior abdominal wall. The sigmoid arteries furnish the vascular supply.

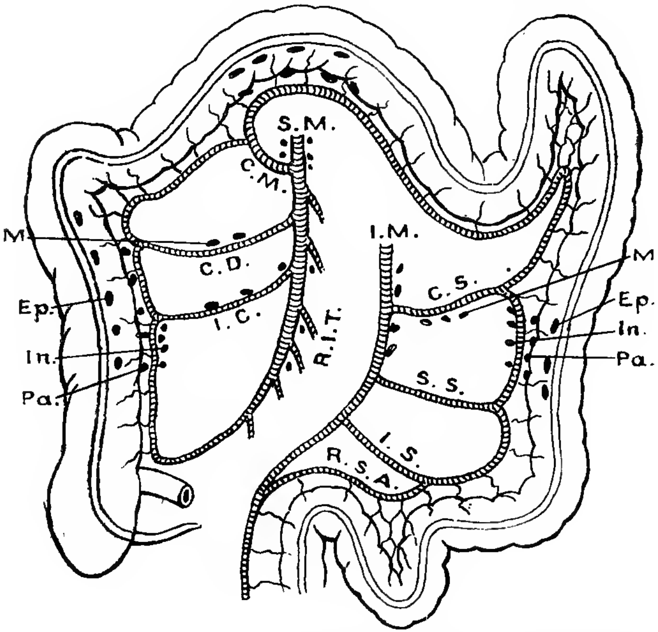
Blood-vessels and Lymphatics—The arterial supply is furnished by the superior and inferior mesenteric branches of the abdominal aorta. The *superior mesen-*

teric arises half an inch below the origin of the cœliac axis, crosses the uncinate process of the pancreas and the third part of the duodenum lying in the enteric mesentery. It is directed in a curved manner, with the convexity towards the left, as far as the right iliac fossa, where it terminates by anastomosing with its ileo-colic branch. The superior mesenteric vein is on the right side of the artery. The branches are—inferior pancreatico-duodenal, colica media, colica dextra, ileo-colic, and rami intestini tenuis (see page 261). The colica media and colica dextra often arise by a common trunk, the media passing downwards and forwards in the transverse meso-colon to the transverse colon: it divides into a right and left branch which anastomose with the colica dextra and colica sinistra respectively. Directed towards the ascending colon, the colica dextra divides into two, ascending and decending, and anastomoses with the colica media and the ileo-colic. The ileo-colic runs downwards and to the right; its terminal branches are ascending and descending, the latter giving off ileal, anterior and posterior cæcals, and the appendicular (see page 263).

The *inferior mesenteric* springs from the aorta about one and a half inches above its bifurcation, It descends over the left psoas muscle and then over the left common iliac artery as the superior hæmorrhoidal. Its branches are—colica sinistra and two sigmoids, upper and lower. The colica sinistra passes in front of the lower pole of the left kidney towards the splenic flexure; it anastomoses with the colica media and the upper sigmoid. The sigmoid arteries anastomose with each other, and with the superior hæmorrhoidal, the trunk connecting the lower sigmoid to the superior hæmorrhoidal being termed the recto-sigmoidal arch. When the rectum is excised for malignant disease by the

abdomino-perineal method, the upper segment of bowel is usually converted into an iliac anus. Sometimes, however, the surgeon decides to restore the continuity of the bowel by bringing the upper segment down to the

Fig. 55.—ARTERIES AND LYMPHATICS OF THE LARGE INTESTINE.



C.D. Colica Dextra Artery. C.M. Colica Media Artery. C.S. Colica Sinistra Artery. Ep. Epicolic Glands. I.C. Ilio-Colic Artery. I.M. Inferior Mesenteric Artery and Branches. In. Intermediate Glands. I.S. Inferior Sigmoid Artery. M. Main Glands. Pa. Paracolic Glands. R.I.T. Rami Intestini Tenuis Arteries. R.S.A. Recto-Sigmoidal Arch. S.M. Superior Mesenteric Artery and Branches. S.S. Superior Sigmoidal Artery.

healthy intestine below; in order to preserve the blood supply of the sutured bowel he must ligate the superior hæmorrhoidal on the proximal side of the recto-sigmoidal arch.

The portal vein commences behind the neck, and in front of the head of the pancreas. It is formed by the confluence of the splenic and the superior mesenteric veins. The vein passes behind the first part of the duodenum, enters the gastro-hepatic omentum, and runs in front of the foramen of Winslow (epiploic foramen). In this situation the common bile duct is on its right side, and the hepatic artery on the left. The vein enters the liver at the transverse fissure. Three tributaries open into the portal—namely, the cystic, coronary (left gastric), and pyloric (right gastric) veins.

The inferior mesenteric vein lies on the left side of its artery, and opens into the splenic. In the enteric mesentery are found the *lymphatic glands* of the small intestine. There are three groups—(*a*) on the wall of the intestine; (*b*) accompanying the rami intestini tenuis vessels; and (*c*) a main set around the upper part of the superior mesenteric. Four sets of glands are in relation to the colon (Jamieson and Dobson)—(*a*) epiploic, in the appendices epiploicæ; (*b*) paracolic, along the inner margin of the ascending and descending colon and the lower margin of the transverse colon; (*c*) intermediate, around the branches of the colic arteries; and (*d*) main, on the ileo-colic, colica media, colica dextra, and colica sinistra vessels.

The lymph from the large bowel to the right of the middle of the transverse colon, drains into the glands along the upper part of the superior mesenteric, the rest passes to the glands on the inferior mesenteric.

The efferents from the superior mesenteric glands go to the intestinal trunk, which opens into the receptaculum chyli, while the inferior mesenteric glands drain into the left lumbar chain of the aorta.

The Posterior Abdominal Wall.—This may be said to be formed by the lumbar region of the spine, and the

muscles which fill in the space intervening between the last rib and the crest of the ilium. The muscles are the psoas magnus, psoas parvus, quadratus lumborum, erector spinæ, and the backward prolongations of the antero-lateral muscles of the abdominal wall.

The external oblique extends almost as far as the middle of the iliac crest, a small interval being left between it and the latissimus dorsi.

This space is known as the *triangle of Petit.* The base of the triangle is formed by the iliac crest, and its floor by the internal oblique muscle. Here a lumbar abscess may point, or more rarely, a hernia protrude.

The posterior aponeurosis of the transversalis muscle becomes the *fascia lumborum*, which is attached above to the last rib and below to the crest of the ilium, while internally it divides into three laminæ, which enclose two compartments — the anterior for the quadratus lumborum, and the posterior for the erector spinæ (Fig. 46). The anterior lamina joins the lumbar vertebræ at the junction of the transverse processes with the bodies; the middle lamina is fixed to the tips of the transverse processes, whilst the posterior lamina is attached to the spinous processes.

Fascia of the Psoas.—This is fixed to the bodies of the vertebræ internal to the origin of the psoas magnus muscle (see page 226); lower down it is attached to the brim of the pelvis. Superiorly, the fascia is continuous with the ligamentum arcuatum internum of the diaphragm; below and externally, it is continuous with the fascia of the iliacus. Inferiorly, it passes beneath the inguinal (Poupart's) ligament, to form the posterior layer of the sheath of the femoral vessels.

A psoas abscess is due to tubercular disease of the bodies of the lower thoracic or lumbar vertebræ. When the condition arises in the lumbar region, the pus may

immediately enter the substance of the psoas muscle, but when it originates in the thoracic vertebræ, the pus passes beneath the ligamentum arcuatum internum of the diaphragm, to reach the sheath of the psoas. Here the abscess burrows downwards towards the iliac fossa, destroying the psoas extensively, but is prevented from extending into the pelvis by the attachment of the fascia to the pelvic brim. In the iliac fossa, the pus forms a large fluctuating swelling beneath the iliac fascia. The abscess may then follow the ilio-psoas and anterior crural nerve beneath the inguinal (Poupart's) ligament lying to the outer side of the femoral vessels ; and lastly, it usually extends inwards, beneath the vessels, to the inner side of the thigh by following the course of the profunda artery.

"A Psoas abscess, when fully developed, usually consists of four parts—a narrow track in the upper part of the psoas muscle, a wide expansion in the iliac fossa, a second narrow part extending beneath Poupart's ligament and the femoral vessels, and a large cavity on the inner side of the thigh" (Erichsen). In patients suffering from psoas abscess, the thigh is flexed to relax the ilio-psoas, and thereby prevent pressure on the lumbar nerves which lie in the sheath of this muscle.

ILIAC ARTERIES.

Common Iliac Artery.—The aorta bifurcates into the common iliac arteries a little to the left of the middle line, opposite the body of the fourth lumbar vertebra, this being on a level with the highest points of the iliac crests. The artery extends as far as the lumbo-sacral articulation, where it divides into the internal and external iliacs.

In front of each artery are the intestines and peri-

toneum, while the ureter crosses the vessel near its bifurcation. The left artery has an additional anterior relation, namely, the superior hæmorrhoidal vessels. The left vein lies internal to the left artery, and then passes beneath the right artery to unite with the right vein, so as to form the inferior vena cava. On the right side the vein lies first beneath, and then to the outer side of the artery. Behind each artery we find the bodies of the fourth and fifth lumbar vertebræ, the psoas muscle, and the sympathetic cord.

External Iliac Artery.—This artery extends from the lumbo-sacral articulation to Poupart's (inguinal), ligament. In its course it runs along the brim of the pelvis, frequently dipping into that cavity. The length of the artery is about three and a half inches.

Relations—

Anterior

Peritoneum.
Ileum (right artery); pelvic colon and iliac colon (left artery).
Ureter (sometimes).
Genital branch of genito-femoral nerve.
Internal spermatic or ovarian vessels.
Deep circumflex iliac vein.

External	*Internal*
Genito-femoral nerve.	External iliac vein.
	Vas deferens, or round ligament of uterus.

Posterior

Ilio-psoas and fascia.
Obturator nerve (in upper part).

Two branches are given off from the external iliac—the inferior epigastric and the deep circumflex iliac. They have been described along with the abdominal parietes (see p. 229).

Ligature of External Iliac.—The artery may be reached by the transperitoneal route, the incision being made through the linea semilunaris, or it may be exposed by an extra-peritoneal method. Kocher ligates the artery by an incision immediately above and parallel with the middle third of Poupart's (inguinal) ligament. After division of the superficial structures and the superficial epigastric vessels, the aponeurosis of the external oblique is split, the internal oblique and transversalis muscles detached upwards, and the fascia transversalis laid bare. The fascia is divided cautiously, and the artery recognised. Avoid the deep circumflex iliac vein, and the femoral branch of the genito-femoral nerve; pass the needle from the external iliac vein, *i.e.* from within outwards. The collateral circulation is very free, being carried on by—(*a*) the inferior and superior epigastrics: (*b*) deep circumflex iliac, ilio-lumbar, and last lumbar branch of the aorta: (*c*) internal pudic and external pudic: (*d*) obturator and internal circumflex: (*e*) superior and inferior glutæals, and the circumflexes.

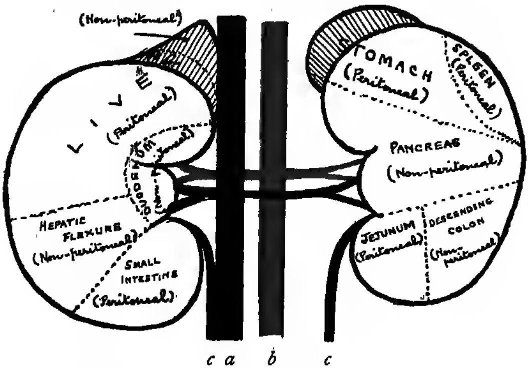
Internal Iliac Artery.—The internal iliac artery extends from the lumbo-sacral articulation to the upper part of the great sacro-sciatic notch, where it divides into anterior and posterior divisions. It is covered in front by the peritoneum and the ureter. Behind, are the internal iliac vein, and parts of the piriformis and sacral plexus. On the outer side is the external iliac vein separating it from the psoas muscle.

Branches.—The anterior divison gives off the superior vesical, middle hæmorrhoidal, inferior vesical, obturator, internal pudic (pudendal) and sciatic (inferior glutæal), while three branches spring from the posterior division, namely, the superior glutæal, lateral sacrals, and the ilio-lumbar.

THE URINARY TRACT.

The Kidney.—The kidneys are situated behind the peritoneum in the paravertebral recesses, and lie opposite the bodies of the last thoracic and the first three lumbar vertebræ: the right organ usually being half an inch lower than the left. Each occupies the following regions:—the hypochondrium, epigastrium, lumbar, and

Fig. 56.—Diagram showing Anterior Relations of Kidneys and Arrangement of Renal Vessels.



a, Inferior Vena Cava. *b*, Aorta. *c c*, Ureters.

umbilical. In the male the paravertebral recesses are deep and funnel-shaped, in the female they are shallow and cylindrical. On an average, the inferior poles of the kidneys are found from one, to one and a half inches above the highest part of the iliac crest. They are placed obliquely, the long axis being directed downwards, outwards, and slightly forwards. The respiratory excursion of a normal kidney varies between one, and one and a half inches.

Average Dimensions (in Adult).

Length . .	=	$4\frac{1}{2}$ inches.
Greatest Breadth	=	$2\frac{1}{2}$ inches.
Thickness . .	=	$1\frac{1}{4}$ inches.
Weight . .	=	$4\frac{1}{2}$ ounces (slightly less in females.)

The hilum is found on the internal border; it is the mouth of a deep recess, the renal sinus. Lodged within the sinus are the renal vessels and the ureter; from before backwards the arrangement is vein, artery and ureter.

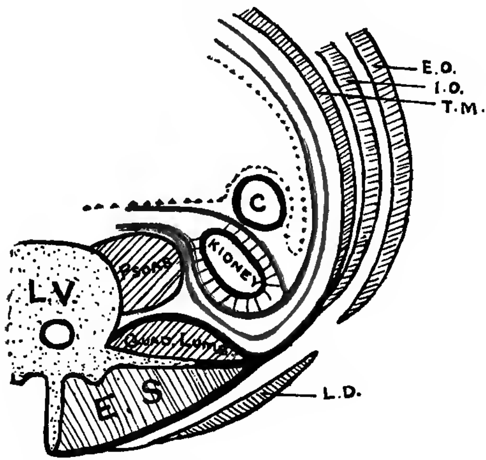
Relations of Kidney.—The anterior relations of the right kidney are—liver, second part of the duodenum, hepatic flexure of the colon, small intestine, and right suprarenal capsule. In front of the left kidney are the stomach, pancreas, spleen, jejunum, descending colon, and left suprarenal. The precise relations these viscera have to the kidney are illustrated in Fig. 56.

Behind each organ are the psoas, quadratus lumborum, diaphragm, and transversalis muscles, covered by their respective fasciæ; the last dorsal nerve and the subcostal artery; the ilio-hypogastric and ilio-inguinal nerves; the twelfth rib and the transverse processes of the first three lumbar vertebræ. Remember also that the pleural cavity passes down below the last rib for a variable distance, and so forms an important surgical relation.

Fascial Investments of the Kidney.—The fibrous capsule covers the exterior of the kidney and lines the sinus. In health it can readily be stripped from the viscus, except at the deepest part of the sinus. The adipose capsule lies external to the fibrous layer; it also completely encloses the organ and dips into the sinus. It is most marked around the lower pole of the organ, and is not developed until the tenth year. Before

that age rupture of the kidney is very apt to be complicated by a tearing of the overlying peritoneum. Lastly, in the neighbourhood of the kidney the extra-peritoneal fat becomes condensed, forming the fascia renalis (Gerota). This fascia splits at the outer border of the organ into two lamellæ, which embrace the adipose

Fig. 57.—DIAGRAM OF RENAL FASCIA.



Fascia Transversalis in green.
Sub-peritoneal Tissue and Renal Fascia in red.
Peritoneum in blue.
E.O. External Oblique. I.O. Internal Oblique,
T.M. Transversalis Muscle. E.S. Erector Spinæ.
L.D. Latissimus Dorsi. C. Colon.
L.V. Lumbar Vertebra

capsule and the kidney. The anterior lamella passes over the renal vessels to blend with the corresponding lamella of the opposite side; the posterior layer lies behind the renal vessels, and fuses with the prevertebral connective tissue. Vertically, the fascia renalis can be traced upwards over the suprarenal gland to become continuous with the posterior layer, while followed down-

wards, the lamellæ disappear in the fat over the iliacus muscle. It is said that a small slip joining the two lamellæ intervenes between the upper pole of the kidney and the suprarenal, but I have never been able to demonstrate it. Connective tissue strands pass through the adipose tissue uniting the fibrous capsule to the fascia renalis; they are especially strong in the vicinity of the lower pole. Rupture, or atrophy of these bands, predisposes to movable kidney, the displaced viscus passing forwards and inwards.

On the left side of the body, the perirenal fascia is strengthened by the remnants of the primitive fusion of the descending colon with the neighbouring parietal peritoneum.

According to Thomson Walker the following factors combine to support the kidney and prevent displacement: (*a*) the renal vessels; (*b*) the peritoneum; (*c*) the attachment of the retro-peritoneal surfaces of the duodenum, colon, and pancreas; (*d*) the adhesions to the suprarenal capsule; (*e*) the fascia renalis and the network of firm fibres which pass from it to the renal capsule; (*f*) the perirenal fat; (*g*) the fascia of Toldt, which connects the fascia renalis on the right side with the hepatic flexure and the duodenum, and on the left, with the splenic flexure; and (*h*) the intra-abdominal pressure.

Renal Vessels.—The right renal artery passes behind the inferior vena cava, the head of the pancreas, and the descending part of the duodenum; the left artery lies behind the body of the pancreas. A short distance from the hilum the arteries divide into several branches which penetrate the organ independently. In the kidney the vessels are arranged into two groups, anterior and posterior. Incisions into the renal cortex are made half an inch behind its outer border (the line of Hyrtl) so

as to penetrate between the two vascular systems. Besides supplying the kidney, each renal artery sends a branch to the corresponding suprarenal capsule, one to the upper part of the ureter, and some perinephric twigs to the adipose capsule.

The renal veins terminate in the inferior vena cava, the left vein running superficially to the aorta.

Abnormal renal arteries are sometimes present. Surgically they are important because they lead to hydronephrosis.

The Ureter.—In the renal sinus the upper part of the ureter becomes expanded as the pelvis. This splits into two or three stems, which in turn divide into short, cup-shaped recesses, the calices. On an average the pelvis has a capacity of three and a half drachms. From the hilum the ureter descends upon the psoas, crosses the bifurcation of the common iliac artery, and enters the pelvic cavity. Here it passes anterior to the internal iliac artery, the obturator vessels and nerve, and the obliterated hypogastric. Lastly, curving inwards, it runs behind the vas deferens and descends on the posterior wall of the bladder, to enter that organ about one and a half inches above the base of the prostate. The ureters pierce the vesical wall very obliquely and open by two small slit-like orifices.

In the abdomen the peritoneum and the ileum, or the pelvic colon, lie in front of the ureter. It is also crossed by the internal spermatic vessels.

Normally, the ureter is narrowed at three places—(*a*) at its junction with the renal pelvis; (*b*) where it crosses the common iliac artery; (*c*) at its entrance into the bladder.

The length of the ureter is about twelve inches. The blood-supply is derived from the renal, internal spermatic, common iliac, and inferior vesical arteries.

Lymphatics of the Kidney and Ureter.—The lymphatics of the kidney communicate freely with those of the adipose capsule, and, accordingly, in renal sarcoma this capsule must be removed with the kidney. They drain into the lumbar glands, these being situated along the course of the inferior vena cava and the aorta. The abdominal section of the ureter drains into the lumbar nodes, whereas the pelvic portion sends its efferents to the iliac and hypogastric glands. (*See* Pelvis.)

The Bladder.—The shape and relations of the bladder vary with the degree of emptiness or distension of the viscus. In children the upper half of the bladder is an abdominal organ.

When empty, the bladder lies entirely in the pelvic cavity, and appears triangular on sagittal section, with the apex directed upwards and forwards towards the symphysis pubis, and the base downwards and backwards towards the rectum. During distension, the bladder becomes ovoid and rises above the brim of the pelvis, so as to come into contact with the anterior abdominal wall. By this means the peritoneum is stripped upwards, so that in complete distension a non-peritoneal area of the anterior abdominal wall exists for two inches in the middle line above the symphysis. Through this area suprapubic aspiration of the bladder is performed.

Three surfaces are described—superior, basal, and infero-lateral.

Relations.—The *superior* surface is covered by peritoneum, and is impressed by the pelvic colon and a few coils of small intestine. The peritoneum leaves this surface along the urachus to reach the anterior abdominal wall.

Separating the *basal* surface from the rectum are the vesiculæ seminales, the vasa deferentia, and the recto-

vesical layer of pelvic fascia. The peritoneum extends down the basal surface as far as the attachment of the ureters. Here it leaves the bladder, forms the floor of the recto-vesical pouch, and passes on to the anterior wall of the rectum.

The *infero-lateral* surface is devoid of peritoneum. It is in relation with the body of the pubic bone, the retro-pubic pad of fat, and the fasciæ clothing the obturator internus, and the levator ani muscles. Connecting it to the pubes are two bands of pelvic fascia, the pubo-prostatic, or anterior true ligaments of the bladder.

Laterally the bladder is crossed by the obliterated hypogastric arteries and the vasa deferentia. Above the obliterated hypogastric artery each margin is covered by peritoneum; but below it is bare, and is joined by the vesical layer of the pelvic fascia, which forms the lateral true ligaments of the bladder.

The *neck* of the bladder, from which the urethra is given off, lies in front of the base, occupying the most dependent position of the viscus.

Structure of the Bladder.—The *muscular coat* consists of fibres which interlace in all directions; many of them are longitudinal, and constitute the *detrusor vesicæ*. The deeper strands are circular, and are increased in number around the neck of the bladder, forming the *sphincter vesicæ*.

When there is any obstruction to the urinary outflow the muscular fibres hypertrophy, giving rise to the appearance known as *fasciculated bladder*. In such cases the bladder is distended, the mucous membrane tends to bulge outwards between the bundles, forming small pouches, thus constituting a *sacculated bladder*. Owing to ammoniacal decomposition of the urine, phosphatic calculi may develop in these recesses.

The *mucous membrane* of the bladder is fixed to the muscular layer by means of a submucous coat. This attachment is loose over the greater part of the organ, and allows the membrane to be thrown into rugæ when the viscus is empty. At the base of the bladder, however, in the region of the trigone, the mucous membrane is closely adherent to the muscular coat and always remains smooth. The trigone is bounded above by the inter-ureteric bar, or bar of Mercier, a prominent muscular ridge bearing the slit-like orifices of the ureters: laterally by two faint elevations produced by the muscles of Bell; and below, the apex is represented by the internal meatus leading into the prostatic urethra. Note the position of the internal meatus, which lies opposite the middle of the symphysis pubis, and about one inch behind it. The trigone is the most sensitive portion of the bladder. At the urethral opening a small elevation, the *uvula vesicæ*, is often found, having behind it a shallow depression which is well marked when the prostate is enlarged; in this a calculus may be lodged.

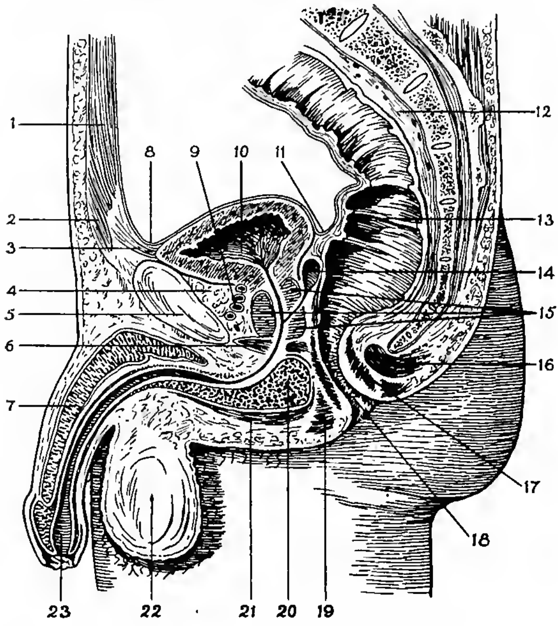
On cystoscopic examination, the trigone is pink in colour owing to the numerous anastomosing vessels in its mucosa, the rest of the bladder has a faint yellowish appearance.

Nerves and Blood-vessels of the Bladder—The bladder receives two sets of nerves: (*a*) the hypogastric nerves from the inferior mesenteric sympathetic plexus; stimulation of these branches causes contraction of all the circular muscle fibres: (*b*) from the second and third sacral nerves along the nervi erigentes. When the latter are stimulated the detrusor contracts and the sphincter relaxes, thus micturition occurs.

The arterial supply comes from the superior and inferior vesical branches of the internal iliac.

Lymphatics of the Bladder.—Neither the ureter nor the bladder have any lymphatic vessels in their mucous

Fig. 58.—Vertical Section of Male Pelvis. (After E. H. Taylor.)



1. Rectus Abdominis Muscle.
2. Pyramidalis Muscle.
3. Urachus.
4. Space of Retzius.
5. Sympbysis Pubis.
6. Interval between Triangular Ligament and Parietal Layer of Pelvic Fascia; the Compressor Urethræ Muscle is shown.
7. Corpus Cavernosum.
8. Anterior reflection of Peritoneum.
9. Part of Pudendal Venous Plexus.
10. Cavity of Bladder (nearly empty).
11. Recto-vesical Pouch of Peritoneum.
12. Pre-sacral Tissue.
13. Interior of Rectum.
14. Vas Deferens.
15. Prostate (the upper posterior portion represents the so-called Middle Lobe).
16. Ano-coccygeal Body.
17. Internal Sphincter Muscle.
18. Anal Canal.
19. External Sphincter Muscle.
20. Bulb of Corpus Spongiosum.
21. Bulbo-cavernosus Muscle.
22. Testis in Scrotum.
23. Fossa Navicularis.

membrane, but vessels are found in the muscular coats. Two small groups of nodes occur in connection with

the bladder: (*a*) anterior vesical, near the apex of the viscus, and along the course of the superior vesical artery, and a minute gland behind the pubes; (*b*) lateral vesical, situated near the obliterated hypogastric. Both sets drain into the iliac and hypogastric nodes.

The Urethra.—The male urethra is about eight inches long; the prostatic portion being one and a quarter inches, the membranous portion three-quarters of an inch, and the remainder or spongy portion six inches. As a whole, the canal presents two curves, the permanent one lying between the internal meatus and a point immediately above the perineo-scrotal junction; the temporary one extends from the latter level to the external meatus.

Examine first the *prostatic part.* It intervenes between the internal meatus and the parietal layer of pelvic fascia. The prostatic urethra is almost vertical in direction; in cases of prostatic enlargement, however, it becomes curved, the concavity being usually directed towards the symphysis. On the floor is a salient ridge of erectile tissue, the verumontanum or crista urethralis; running upwards and backwards from it is a small cul-de-sac, the sinus pocularis (prostatic utricle). The verumontanum divides the prostatic urethra into two lateral recesses, the prostatic sinuses, into which the minute prostatic ducts open. In shape this portion of the canal is fusiform; it is the widest and most dilatable section of the urethra.

The *membranous part* extends from the parietal layer of pelvic facia to the triangular ligament. It is surrounded by the compressor urethræ or sphincter of the membranous urethra, and is consequently a narrow portion of the canal.

Lying in front of the triangular ligament, the *spongy urethra* is subdivided into the meatal, navicular, penile,

scrotal, and bulbous areas. It is dilated in the navicular and bulbous sections, while the external meatus is the narrowest part of the urethra. The ducts from Cowper's (bulbo-urethral) glands open into the bulbous portion.

The mucous membrane of the urethra is studded with small glands, known as the glands of Littré; the majority open into the lacunæ. The openings of the latter are directed forwards. They lie, most commonly, on the floor of the urethra, and are especially numerous in the bulbous part. One large recess, however, the lacuna magna, lies in the roof of the fossa navicularis. This lacuna should be avoided when introducing a catheter of small calibre.

Except during the passage of urine or semen, the walls of the urethra are always in apposition. In the fossa navicularis the lateral walls are in contact; in the remaining portions the anterior and posterior walls approach each other.

Organic strictures occur most frequently in the bulbous area, just in front of the triangular ligament. In the erect posture this part is dependent, and forms a "well" between the anterior and posterior sections of the urethra in which discharges may accumulate and cause irritation. Organic strictures are occasionally found near the external meatus, but never in the prostatic portion. In the membranous urethra organic stricture is rare, and when present, is almost invariably of traumatic origin.

THE PROSTATE GLAND.

The prostate is a fibro-muscular organ surrounding the first part of the urethral canal. Insignificant in size before the onset of puberty, it develops *pari passu*

with the testis. In old age it is apt to undergo senile changes, these generally resulting in the gradual enlargement of the gland. The gland lies between the symphysis pubis and the rectum, and is about one and a half inches from the anus. Its posterior surface can therefore be examined by introducing the finger into the rectum and directing it towards the pubes. No doubt the close proximity of the prostate to the rectum explains the intense pain experienced during defæcation by patients suffering from prostatitis.

The prostate is invested by certain portions of the pelvic fascia and by the perivascular connective tissue of the surrounding vessels. This fascial envelope is termed the sheath of the organ. On the anterior aspect the sheath is formed by the dense tissue in which the pudendal plexus is embedded: laterally, by the pelvic fascia clothing the upper surface of the levator ani, and behind, by the blending of the recto-vesical layer of pelvic fascia with the fascia of Denonvillier, the latter being derived from the peritoneum which in the fœtus extends along the anterior surface of the rectum. At the prostatic apex the sheath fuses with the pelvic aspect of the triangular ligament, *i.e.*, with the parietal layer of the pelvic fascia. The sheath is only loosely connected to the gland except at—(*a*) the apex; (*b*) the middle of the anterior surface; and (*c*) the vesico-prostatic groove. The upper surface of the prostate is not covered with pelvic fascia, but lies immediately beneath the internal sphincter and the mucous membrane of the bladder. Within the sheath is the true capsule or cortex; it is a portion of the stroma devoid of glandular tissue which cannot be separated from the rest of the organ. (Shattock).

The average dimensions of the prostate in the adult are:—

Vertical	=	$1\frac{1}{4}$ inches.
Transverse	=	$1\frac{1}{2}$ inches.
Antero-posterior	=	$\frac{3}{4}$ inch.
Weight	=	$4\frac{1}{2}$ drachms.

Four surfaces—anterior, posterior, and two lateral, an apex, and a base—may be described. The base is separated from the bladder by the vesico-prostatic groove in which rest large anastomosing veins, the pudendal plexus. As previously mentioned, the apex is in contact with the parietal layer of pelvic fascia.

Relations.—*Anterior.*—The lower part of the symphysis pubis, the pudendal plexus, the retro-pubic pad of fat, and the space of Retzius with the dorsal vein of the penis; *superior*—the bladder, the seminal vesicles, and the ampullæ of the vasa deferentia; *inferior*—the parietal layer of the pelvic fascia; *laterally*—the levator ani muscles; *posterior*—the space of Denonvillier and the rectum. The space of Denonvillier is limited below by the recto-urethralis, a muscular slip connecting the longitudinal fibres on the anterior aspect of the rectum in its lower part to the compressor urethræ.

Three structures traverse the prostate, the urethra towards the front of the gland and the common ejaculatory ducts in the posterior portion. That part of the organ which lies in front of the urethra is termed the anterior commissure; it does not contain any secreting tissue.

The area including the common ejaculatory ducts is often called the posterior lobe, the part between the ejaculatory ducts and the urethra is the middle lobe, while flanking the urethra are the lateral lobes.

Senile Enlargement.—The usual form of senile enlargement is a glandular hyperplasia most commonly involving the middle lobe. This slowly enlarges, becomes surrounded by a layer of atrophied fibrous and

glandular tissue, the "false capsule." In the majority of cases the overgrown middle lobe herniates itself through the vesical sphincter, and appears beneath the mucous membrane as a rounded tumour lying posterior to the internal meatus, displacing the common ejaculatory ducts backwards. This intra-vesical projection considerably interferes with micturition. In addition, the prostatic urethra is elongated, and becomes markedly curved, the concavity being directed towards the pubes. Suprapubic prostatectomy consists in enucleating the enlarged glandular mass from its "false capsule."

Functions of the Prostate.—The prostatic fluid is alkaline in reaction. It is secreted by tubular glands lined by columnar epithelium. There are from fifteen to twenty ducts which open into the prostatic sinuses on each side of the verumontanum. Many theories are held regarding the functions of the prostatic fluid; the chief being that the secretion—(*a*) lubricates the posterior urethra; (*b*) dilutes the semen; (*c*) stimulates the spermatozoa; (*d*) provides an alkaline medium for the spermatozoa, and thus neutralises the acid secretion of the vagina. Owing to its position the gland mechanically supports the neck of the bladder and the first part of the urethra.

Vascular Supply.—This is derived mainly from the inferior vesical and middle hæmorrhoidal arteries. Only small twigs penetrate the gland, which is not a vascular organ (Cuthbert Wallace). The venous plexus is embedded between the sheath and the cortex, and is found on the anterior and lateral aspects of the prostate. In old people these veins often become enormously dilated, and phleboliths are common. The dorsal vein of the penis terminates in the pudendal plexus, while the plexus itself opens into the internal iliac veins.

Lymphatics and Nerve Supply.—Lymphatic vessels

commence in networks around the acini of the gland, and drain into the iliac, hypogastric, and sacral nodes.

The nerve supply is furnished by the hypogastric plexus.

The Prostatic Utricle, or sinus pocularis, is a cul-de-sac, $\frac{1}{4}$-$\frac{1}{2}$ inch long, which is directed upwards and backwards into the prostate, from the verumontanum of the prostatic urethra. Within its margins open the common ejaculatory ducts. The utricle corresponds to the vagina, uterus, and Fallopian tubes; its margins represent the hymen.

Vesiculæ Seminales.—The vesiculæ seminales are two glandular organs situated on the basal surface of the bladder. Each is two inches long, as it lies *in situ*. The vasa deferentia lie along the inner side of the seminal vesicles. The ampullæ of the vasa are remarkably convoluted and serve as seminal reservoirs. Both the seminal vesicles and the vasa deferentia are ensheathed by the recto-vesical layer of pelvic fascia. A common ejaculatory duct results from the junction of a vas deferens with a seminal vesicle. Acute inflammatory conditions of the vesiculæ seminales are usually of gonorrhœal origin, while chronic inflammation is almost always associated with tubercular epididymitis.

Cowper's (Bulbo-Urethral) Glands.—These are small, yellow bodies, about the size of a pea, flanking the walls of the membranous urethra. The duct from each gland is about one inch long, and pierces the triangular ligament to open into the bulbous urethra. The glands usually atrophy after middle age.

THE PELVIC PORTION OF THE ALIMENTARY CANAL.

Pelvic Colon.—The pelvic colon is a continuation of the iliac colon, and extends from the brim of the pelvis

to the body of the third sacral vertebra, where it becomes the rectum. In length it varies on an average between fourteen and seventeen inches, although it may be as short as five inches. It is fixed to the pelvic wall by an elongated fold of peritoneum, the pelvic meso-colon, which contains the superior hæmorrhoidal vessels. Sometimes the pelvic colon is twisted around the axis of its mesentery, a condition known as volvulus.

The pelvic colon crosses the external iliac vessels and rests upon the upper surface of the bladder or uterus; when of usual length two limbs, ascending and descending, are found. In Stiles' operation for ectopia vesicæ, the left ureter is implanted into the ascending limb, and the right ureter into the descending limb.

The basal attachment of the pelvic meso-colon is short and somewhat Λ-shaped. It first ascends from the inner border of the left psoas to just below the bifurcation of the left common iliac artery, then turns acutely to descend along the anterior aspect of the sacrum as far as the third segment, a place about five inches from the anus. The position of the inter-sigmoid fossa has been previously referred to (page 244).

Rectum.—The rectum proper becomes the anal canal at a point one and a half inches beyond the tip of the coccyx; it is from five to six inches in length. Notice that its external characters differ from the pelvic colon, as it is not sacculated, and both the tænia coli and the appendices epiploicæ are absent. The upper third of the rectum is covered by the peritoneum in front and laterally, the middle third only in front, while the lower third is entirely bare.

Relations.—In *front* will be found the recto-vesical pouch; and at a lower level, the base of the bladder with the seminal vesicles and the vasa deferentia, and the posterior surface of the prostate; the viscera are

separated from the rectum by the recto-vesical layer of pelvic fascia and by the fascia of Denonvillier. *Behind* are the sacrum and coccyx, the levatores ani muscles, and the ano-coccygeal body. *Laterally*, in the upper third are the pararectal peritoneal fossæ (when the rectum is empty), and below this the levatores ani.

The distance of the recto-vesical pouch from the anal orifice is about two and a half inches, if the bladder be empty, and about an additional inch when it is distended (Cripps).

The lateral flexures of the rectum produce the valves of Houston seen in the interior. They are three in number; the usual arrangement being, the middle valve is on the right side, and the superior and inferior valves on the left. "In addition to supporting the fæces, these foldings greatly increase the capacity of the rectum without unduly dilating the tube" (Birmingham). It is stated that the inferior valve may interfere with the passage of a rectal bougie.

At its upper part the lumen of the rectum is rather smaller than that of the pelvic colon, but a little above the anus the tube becomes greatly dilated, and in this *ampulla* considerable fæcal accumulations may lodge.

The Anal Canal.—The anal canal projects downwards and backwards from the ampulla of the rectum to the perineum. It is "an antero-posterior slit in the pelvic floor, its lateral walls being in apposition; it differs in this respect from the lower part of the rectum, which, when empty, appears as a transverse slit" (Symington). The length of this portion of the alimentary tract in adults varies from three-quarters of an inch to one and a quarter inches. The internal sphincter is a thickening of the circular muscle fibres of the bowel surrounding the greater part of the canal; the place where it joins the external sphincter is marked by a

slight elevation, the white line of Hilton, which also corresponds to the muco-cutaneous junction. A series of vertical ridges (columns of Morgagni) will be seen on the mucous aspect. Each contains a twig from the superior hæmorrhoidal artery. In the upper part of the canal the mucous membrane between the columns forms the so-called "anal valves," a tear of one of which is the starting-point of an anal fissure (Ball), the valve-tag giving origin to the "sentinel-pile" of Brodie. The external sphincter arises from the tip of the coccyx, and is inserted into the central point of the perineum. Its nerve-supply is derived from the inferior hæmorrhoidal and fourth sacral nerves.

In certain anomalous conditions of the lower bowel the anal canal is absent, or is represented by a small dimple. In such cases a slight annular pigmentary area will indicate the site where the anus ought to have developed.

To make a digital examination of the rectum introduce the finger from behind. First palpate the anterior wall and identify from below upwards:

(i) Bulbous portion of urethra.
(ii) Membranous portion of urethra.
(iii) Apex, and lateral surfaces of prostate gland.

In diseased conditions the surgeon can also recognise Cowper's (bulbo-urethral) glands and the vesiculæ seminales. Now palpate the lateral wall, to examine the ischio-rectal fossa and the bony wall of the true pelvis, and lastly, through the posterior wall feel the anterior surface of the sacrum and coccyx.

Vascular Supply of the Rectum and Anal Canal.—Five hæmorrhoidal arteries are present: (*a*) the *superior* is the continuation of the inferior mesenteric. It runs in the pelvic meso-colon, and opposite the junction of the pelvic colon and rectum, splits into two branches

which pass downwards on the side walls of the rectum; (*b*) two *middle* hæmorrhoidals derived from the internal iliac; and (*c*) two *inferior* hæmorrhoidal branches of the internal pudic (pudendal). Sometimes an additional supply is furnished by the sacra media.

The veins of the rectum are peculiar in their arrangement, and show a marked predisposition to the development of varix (hæmorrhoids).

Near the anus the veins lie in the loose sub-mucous tissue between the muscular layer and the muco-cutaneous surface, and from here they ascend in the columns of Morgagni to form a dense plexus in the lower part of the ampulla. The vessels issuing from the plexus penetrate the muscular wall to unite as the superior hæmorrhoidal vein. The perianal cutaneous veins are tributaries of the inferior hæmorrhoidal. The main anatomical facts leading to the production of hæmorrhoids are—(*a*) the stagnant circulation in the hæmorrhoidal plexus; (*b*) the dependent position of the veins; (*c*) the absence of valves in the portal system; (*d*) the passage of the superior hæmorrhoidal veins through the muscular layer of the rectum, and (*e*) the frequent distension of the ampulla with fæcal contents materially retards the venous return.

Nerve Supply.—This is derived from the hypogastric sympathetic plexus and the second, third, and fourth sacral nerves. The most abundant nerve supply arises from the fourth sacral. These several nerves, together with the right and left branches of the superior hæmorrhoidal vessels are enclosed in a mass of condensed fibrous tissue, and form the rectal stalks (Elliot-Smith). The base of the stalks extends transversely along the front of the sacrum opposite the third or fourth segments.

Lymphatics.—The ano-rectal glands are situated in

the upper part of the rectum. They rest upon the external longitudinal fibres and accompany the superior hæmorrhoidal vessels. Their efferents pass to the meso-colic nodes in the lower part of the pelvic meso-colon, which in turn open into the lumbar glands opposite the origin of the inferior mesenteric artery. The lower part of the anal canal drains into the inguinal glands.

Development of the Rectum and Anal Canal.—The rectum and the upper part of the anal canal develop from the caudal portion of the hind-gut—the entodermal cloaca; the lower part of the anal canal arises from the proctodæum or ectodermal cloaca, a shallow pit immediately in front of the tail-fold. A membrane, the cloacal membrane, separates the proctodæum from the hind-gut; normally it breaks down during the third month. By the subsequent ingrowth and fusion of two lateral folds, the entodermal cloaca is divided into two compartments—a ventral one, the urogenital sinus, and a dorsal one, the rectum. The urogenital sinus forms the bladder and the upper part of the urethra in the male; in females it becomes the bladder, the urethra, and the vestibule of the vagina.

The main congenital malformations of the rectum and anal canal are—(*a*) absence of the anal canal; (*b*) persistence of the cloacal membrane leading to imperforate anus; (*c*) fistulæ between the rectum and some portion of the urogenital sinus; (*d*) absence of the rectum, the pelvic colon ending blindly.

PELVIC LYMPHATIC NODES.

These glands are arranged in three big divisions—namely, iliac, hypogastric, and sacral.

Table of Pelvic Nodes

Group.		Situation.	Termination.
Iliac	Common	(*a*) Outer side of artery (*b*) Between artery and vein (*c*) On sacral promontory, beneath bifurcation of aorta	Lumbar Nodes.
	External	(*a*) Outer side of artery (*b*) Between artery and vein (*c*) Between vein and obturator nerve	
Hypogastric		Accompanying the internal iliac artery and its branches	Into group (*c*) of common iliacs; the obturator gland however opens into group (*c*) of external iliacs.
Sacral		Along middle and lateral sacral vessels, in concavity of sacrum	Into group (*c*) of common iliacs.

THE MALE PERINEUM.

The perineum or pelvic outlet, in the undissected body, is represented by a shallow furrow lying between the buttocks and the thighs. In the dissected subject, however, it forms a somewhat lozenge-shaped area, extending from the symphysis and sub-pubic ligament anteriorly to the tip of the coccyx posteriorly, and

flanked laterally by the conjoined rami of the ischium and pubes, the tuber ischii, and the great sacro-sciatic ligaments. It is customary to subdivide the space into an anterior division called urogenital, and a posterior division named rectal. The plane of separation occurs through a transverse line connecting the ischial tuberosities, one inch in front of the anus.

Surgical Landmarks.—With the body in the lithotomy position identify the structures bounding the pelvic outlet. Examine the coccyx, and ascertain if the sacro-coccygeal articulation be movable or not. Ankylosis of the joint should occur at the thirty-fifth year. Note the external sphincter muscle passing forwards to the anus, and by pressing firmly beneath the margins of the gluteus maximus, the sacro-sciatic ligaments extending laterally to the ischial tuberosities. The symphysis is difficult to palpate, as it is masked by the root of the penis and penile muscles, but the conjoined rami and ischial tuberosities are easily recognised. Notice the median raphé of the perineum. It can be traced from the anus along the scrotum and the under aspect of the penis. The raphé forms a convenient route for reaching the bladder and posterior urethra. The anal orifice is deeply pigmented, and presents a rugose appearance, owing to the presence of a small band of involuntary muscle fibres, the corrugator cutis ani. This muscle inverts the mucous membrane of the anus after it has been everted during defæcation. On either side a small dimple indicates the position of the ischio-rectal fossa. The integument around the anus possesses a loose texture, and frequently displays hypertrophied tags, "dog-ear" piles. It is richly endowed with sweat and sebaceous glands, which may suppurate, forming perianal abscesses. The perianal veins are of importance, as they become very prominent during an attack of piles. A

rupture of one of these vessels leads to the development of a small hæmatoma in the superficial fascia, the thrombotic pile.

Ischio-rectal Fossæ.—Each fossa is somewhat pyramidal in shape, with its apex upwards. In adult subjects the demensions are—

Depth (*i.e.*, base to apex)	=	$2\frac{1}{2} - 3$ inches.
Antero-posterior	=	2 inches.
Transverse	=	1 inch.

Boundaries—Below, the fossæ are covered in by the integument and superficial fascia.

Externally, the obturator internus lined by the obturator fascia—*i.e.*, the parietal layer of pelvic fascia. This wall is almost perpendicular.

Internally, by the levator ani and anal fascia, which, if traced upwards, are found to become attached to the outer wall at the apex of the space, the fossa being thus shut off from the cavity of the pelvis. This wall slopes obliquely inwards towards the rectum.

Anteriorly, we find the pelvic layer of the triangular ligament—*i.e.*, the parietal layer of pelvic fascia.

Posteriorly, the space is completed by the glutæus maximus and the great sacro-sciatic ligament.

Contents—The internal pudic (pudendal) vessels and nerve traverse the outer wall lying in a sheath of the obturator fascia, Alcock's canal. This canal lies one and a half inches above the ischial tuberosity. The nerve is superficial to the vessels in the lithotomy position of the body, and after giving off its inferior hæmorrhoidal branch, divides into the dorsal nerve of the penis and the perineal nerve. Passing forwards towards the scrotum are the superficial perineal artery and nerves. The former, a branch of the internal pudic artery, and the latter, branches of the perineal nerve. Running inwards towards the rectum and anus are the inferior

hæmorrhoidal vessels and nerves, and in the posterior part of the fossa the perineal branch of the fourth sacral nerve and filaments from the small sciatic are found. Large lobulated masses of fat fill up the fossa, and here ischio-rectal abscesses are of frequent occurrence, the pus from which may burrow in several directions:—

(*a*) Towards the base of the fossa and point in the perineum (external rectal sinus).

(*b*) Through the inner wall, passing in the first place between the levator ani and the external sphincter, and afterwards between the external and internal sphincters, discharging into the anal canal (internal rectal sinus).

(*c*) Pass both into the anal canal and on to the perineum (fistula-in-ano).

(*d*) Travel backwards, and work between the rectum and the ano-coccygeal ligaments, reaching the opposite ischio-rectal fossa (horse-shoe abscess).

(*e*) Pass backwards between the rectum and coccyx, and then through the great sacro-sciatic foramen pointing in the gluteal region (gluteal abscess).

(*f*) Burrow upwards through the apex of the fossa, perforating the levator ani and thus entering the pelvis, where it spreads in the peri-rectal connective tissue.

Urogenital Triangle.—In this area we shall have to study the external genital organs. Apart from these, the more important structures met with in the anterior part of the perineum are here named in their order, from the skin towards the pelvic cavity:—

Superficial fascia.

Root of the penis with the superficial perineal muscles, namely, the bulbo-cavernosus, ischio-cavernosus, and transversus perinei.

Triangular ligament.

Membranous part of the urethra, with the compressor

urethræ muscle, internal pudic artery, and Cowper's (bulbo-urethral) glands.

Pelvic layer of the triangular ligament — *i.e.*, the parietal layer of the pelvic fascia.

Anterior margins of the levator ani and the capsule of the prostate.

The *deep layer* of the superficial fascia, or *fascia of Colles*, has certain definite and important attachments. Posteriorly, it winds round the transversus perinei to blend with the posterior border of the triangular ligament. At the sides it is fixed to the rami of the pubes and ischium. In front, this fascia is continuous with the superficial fascia of the scrotum, the sub-cutaneous tissue of the root of the penis, and the fascia of Scarpa.

When the anterior urethra is ruptured, urine is extravasated beneath the fascia of Colles, and is prevented from extending backwards into the ischio-rectal fossæ by the blending of the fascia with the posterior border of the triangular ligament. It is prevented from passing down the inner side of the thigh by the attachment of the fascia to the rami of the pubes and ischium. It therefore travels forwards through the subcutaneous tissue of the scrotum and penis to the anterior abdominal wall, and here it cannot descend on to the front of the thigh, owing to the attachment of the fascia of Scarpa to the fascia lata, just below Poupart's ligament.

The Triangular Ligament.—The triangular ligament is a firm, tough membrane, whose upper edge is in contact with the sub-pubic ligament. The base is directed backwards towards the rectum, and to the base the fascia of Colles is fixed in front, and the pelvic portion of the ligament—*i.e.*, the parietal layer of pelvic fascia, behind. Laterally, the ligament is attached to the rami of the pubes and ischium.

The following structures pierce the triangular ligament: (*a*) the urethra—this opening is situated mesially one inch below the lower edge of the symphysis; (*b*) the artery to the bulb, on each side of the urethral orifice; (*c*) the ducts from Cowper's glands, posterior to the arteries to the bulb; and (*d*) the internal pudic arteries and the dorsal nerves of the penis, near the apex of the ligament. Note that the dorsal vein of the penis passes between the triangular and the subpubic ligaments.

Internal Pudic (Pudendal) Artery. — This vessel arises from the internal iliac, and leaves the pelvis through the great sacro-sciatic foramen to enter the buttock. Here it lies on the ischial spine, having the nerve to the obturator internus on the outer side, and the pudic nerve internally. The artery then disappears through the lesser sacro-sciatic foramen to reach Alcock's canal (*see ante*), where it passes forwards to gain the interval between the triangular ligament and the parietal layer of pelvic fascia; it terminates by piercing the former membrane. The branches are—inferior hæmorrhoidal, superficial perineal, transverse perineal, artery to the bulb, artery to the corpus cavernosum, and the dorsal artery of the penis.

The Scrotum.—The skin of the scrotum is very extensible and vascular; it is occasionally enormously distended by scrotal herniæ or tumours. The surface is marked by *rugæ*, between which dirt or sweat may accumulate, and be the cause of considerable irritation, or even of an eczematous condition. For the same reason the scrotal integument is occasionally the site of epithelioma, especially in paraffin workers.

In tropical regions the scrotal tissues are sometimes greatly swollen, as in the disease, elephantiasis Arabum.

When the scrotum is enlarged the skin of the penis

is drawn downwards with it, so that in extreme cases it may almost disappear from view, as it is attached by its root to the pubes.

The coverings of the scrotum are—integument, superficial fascia with the dartos muscle, intercolumnar fascia, cremasteric fascia, infundibuliform fascia, and the parietal layer of the tunica vaginalis. The superficial fascia forms an imperfect partition, the septum scroti; this separates the tunicæ vaginales of opposite sides. Lymphatics from the scrotum drain into the inguinal nodes.

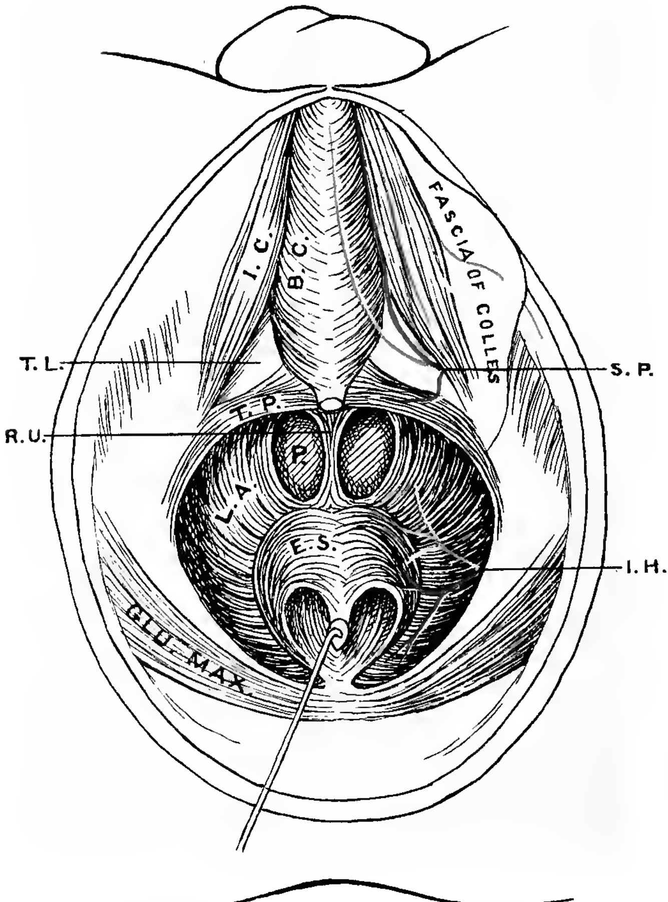
Three arteries ramify in the scrotal tissues, namely, the superficial and deep external pudics from the femoral, and the superficial perineal from the internal pudic.

The Testicle and Epididymis.—The testis and epididymis are covered by the visceral layer of the tunica vaginalis; beneath this the testis has a tough inelastic membrane, the tunica albuginea. The latter is very unyielding, hence the great pain felt in orchitis.

The epididymis lies superior, external, and posterior to the testis. It consists of three parts, the globus major (caput), the body, and the globus minor (cauda). The globus major is the uppermost and receives the vasa efferentia from the testis. Notice that the body is separated externally from the testis by a shallow depression, the digital fossa, while the globus minor is fixed to the testis by areolar tissue and is directly continuous with the vas deferens. This continuity serves to explain how affections extending from the urethra or prostate, such as gonorrhœa, usually involve the epididymis; while inflammatory affections following trauma, as a rule, affect the body of the testis, which lies in front of the epididymis and is therefore more exposed.

In hydrocele, fluid collects between the parietal and

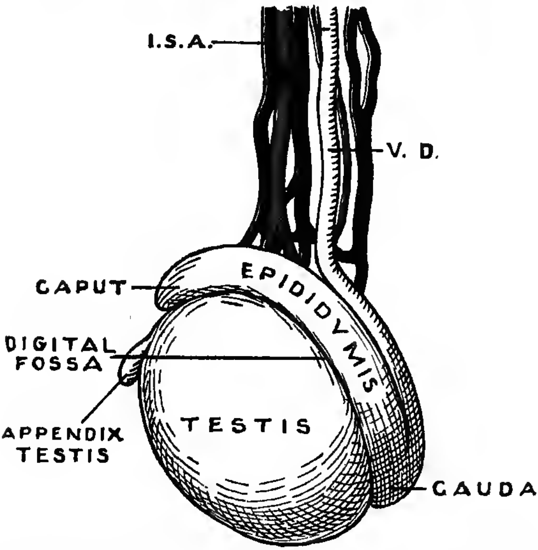
Fig. 59.—Dissection of the Male Perineum.



B.C. Bulbo-cavernosus.
E.S. External Sphincter.
I.C. Ischio-cavernosus.
I.H. Inferior Hæmorrboidal Artery and Nerve.
L.A. Levator Ani.
P. Prostate Gland.
R.U. Recto-urethralis Muscle.
S.P. Superficial Perineal Artery and Nerves.
T.L. Triangular Ligament.
T.P. Transversus Perinei.

visceral layers of the tunica vaginalis, the gland being displaced backwards. In some cases, however, the testis lies in the anterior part of the scrotum, having the epididymis in front and the tunica vaginalis behind it (inversion of the testis). The position of the organ should therefore be determined previous to tapping a

Fig. 60.—The Left Testis and Spermatic Cord.



I.S.A. Internal Spermatic Artery and Pampiniform Plexus of Veins. V.D. Vas Deferens and its Vessels.

hydrocele. In inversion the vas deferens lies in the *anterior* part of the spermatic cord.

From the posterior margin of the testis, the tunica albuginea passes into the organ for a short distance forming a fibrous mass—the mediastinum. This is connected to the front and sides of the tunica albuginea by incomplete fibrous septa which subdivide the testicle

into lobules. The septa and the deep aspect of the tunica albuginea are lined by blood vessels—the tunica vasculosa. Each lobule contains two or more seminal tubules; they become straight tubules, the latter ramifying in the mediastinum as the rete testis. The vasa efferentia issue from the rete testis.

Several development relics are found in the vicinity of the testis and epididymis. They are (*a*) the hydatids of Morgagni fixed to the upper pole of the testis, remnants of the Müllerian duct; (*b*) the paradidymis in front of the lower part of the cord and just above the epididymis, a vestige of the Wolffian body; (*c*) Kobelt's tubules, small blind tubules often found between the vasa efferentia, and which are the remains of Wolffian tubules. Cystic conditions and teratomatous tumours may arise from the paradidymis and Kobelt's tubules.

Two sets of lymphatics, superficial and deep, are found in the testis and epididymis. The ducts accompany the internal spermatic vessels, and terminate in the lumbar glands.

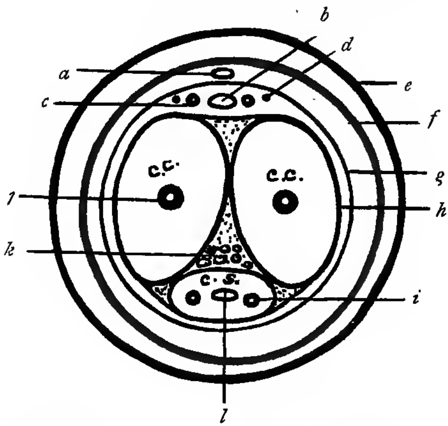
The descent of the testis was described on page 235.

The Penis.—The body of the penis comprises two corpora cavernosa and the corpus spongiosum; the former being placed side by side on the dorsal and lateral aspects of the organ. Notice that the corpus spongiosum is found on the under surface, and that it is tunnelled by the urethra.

Opposite the lower part of the symphysis pubis the corpora cavernosa diverge from each other, and under the name of the crura are attached to the conjoined rami of the ischium and pubes. The corpus spongiosum when followed backwards becomes the bulb, which rests upon the perineal surface of the triangular ligament. Traced forwards the corpus spongiosum forms the glans, the corpora cavernosa stopping short of the corona.

The root of the penis is intimately connected with the superficial perineal muscles, the erector penis (ischio-cavernosus) clothing the crus, and the accelerator urinæ (bulbo-cavernosus) covering the bulb. Each corpus cavernosum is enveloped by a firm elastic sheath, the tunica albuginea, and is separated from its fellow by the septum pectiniforme.

Fig. 61.—Transverse Section of Penis.



a. Superficial Dorsal Vein.
b. Deep Dorsal Vein.
c. Dorsal Artery.
d. Dorsal Nerve.
e. Skin
f. Superficial Fascia and Dartos.
c.c Corpora Cavernosa.
g. Fibrous Sheath.
h. Tunica Albuginea.
i. Artery accompanying Urethra.
j. Artery to Corpus Cavernosum.
k. Septal Vessels.
l. Urethra.
c.s Corpus Spongiosum.

The arrangement of the blood-vessels and nerves is shown in Fig. 61.

Lymphatics of the Penis and Urethra.—The superficial lymphatics of the penis accompany the dorsal vein and end in the superficial inguinal glands. The deep vessels originate in the glands. They also run with the dorsal vein draining into the deep subinguinal glands, one duct passing up the inguinal

canal to terminate in the external iliac nodes. A very complex drainage occurs in connection with the urethra; the prostatic portion terminating in a similar manner to that of the prostate gland; the bulbous and membranous parts finishing in the hypogastric or external iliac chain; while the penile group accompany the dorsal vein of the penis, to end in the deep subinguinal and external iliac nodes.

THE PELVIC FASCIA.

The pelvic fascia is the continuation of the fascia iliaca which is attached to the posterior part of the ilio-pectineal line. From this origin the fascia is prolonged downwards on the inner surface of the obturator internus muscle, gradually descending to reach the lower part of the body of the pubes. The inferior attachments of this parietal layer are the conjoined ischial and pubic rami, the ischial tuberosity, and the great sacro-sciatic ligament. As the pelvic fascia extends across the pubic arch it forms the pelvic layer of the triangular ligament, and thus clothes the compressor urethræ muscle. Stretching from the back of the body of the pubes to the ischial spine is a thickening of the fascia termed the *white line;* the visceral layer of pelvic fascia passes across the pelvic floor joining the "white lines" of opposite sides.

The visceral layer covers the pelvic aspect of the levator ani muscle, and reaching the neck of the bladder splits into three partitions—the vesical, recto-vesical, and rectal layers. The vesical band becomes lost upon the walls of the bladder, and also assists in forming the anterior portion of the sheath of the prostate; the recto-vesical intervenes between the bladder and the rectum, envelops the seminal vesicles and the vasa

deferentia, and forms the posterior portion of the sheath of the prostate. The rectal layer proceeds downwards between the levator ani and the rectum, and then passes backwards to line the posterior wall of the bowel.

Lastly, notice that the vesical layer is connected to the pubes by the pubo-prostatic ligaments. The space between these bands is known as the space of Retzius; it is traversed by the dorsal vein of the penis.

The above description, although not quite in accord with the latest observations, is sufficiently accurate for practical purposes, and hence has been retained.

FEMALE GENITAL ORGANS.

The Uterus.—The normal virginal uterus occupies a position a little to the right of the middle of the pelvis, intervening between the bladder in front and below, and the intestinal canal above and behind. It is slightly anteflexed and anteverted. Two main parts can be distinguished, a body and a cervix. The former presents a dome-like upper extremity, the fundùs, which lies above the entrance of the Fallopian tubes. Frequently a definite constriction, the isthmus, marks the external junction of the body and cervix; it corresponds to the position of the internal os. The cervix is partially thrust into the upper part of the vagina, and therefore presents a supravaginal and a vaginal segment. The cavity of the body is triangular with the apex at the internal os, whereas the cavity of the cervix is fusiform in outline and is termed the cervical canal. It communicates with the vagina by means of an aperture, the external os. This orifice is a transverse slit in nulliparæ,

and has two lips, the anterior being thicker, blunter, and slightly lower than the posterior.

Dimensions—

External length = 3 inches.
„ breadth (greatest) = 2 inches.
Thickness = 1 inch.
Weight = $1\frac{1}{2}$ ounces.

The internal dimensions of the cavity are—

Length = $2\frac{1}{2}$ inches.
Greatest breadth = 1 inch.

The uterus consists of three coats :—(*a*) peritoneal or the *perimetrium ;* (*b*) muscular or the *mesometrium ;* and (*c*) mucous or the *endometrium.* The cervical portion of the endometrium is arranged in folds, the arbor vitæ. Fibro-myomata occurring in the uterus are classified as subperitoneal, interstitial, and submucous according to the coat from which they arise.

Relations.—The position of the uterus varies with the degree of distension of the bladder. As this viscus enlarges, the normal anteversion and anteflexion disappear ; in fact, during extreme distension a condition of retroversion may be assumed. The cervix is more fixed, the external os lying on a level with the upper border of the symphysis pubis.

If we trace the peritoneum, we find that it is reflected from the bladder on to the uterus at the junction of the cervix with the body, thus forming the utero-vesical pouch ; thence it covers the anterior surface of the body, passes over the fundus, and descends along the posterior surface to clothe the posterior wall of the vagina for about half an inch. From this point it is reflected on to the rectum as the recto-uterine pouch (pouch of Douglas). Laterally, it is continued on to the side walls of the pelvis as the broad ligaments. The utero-sacral

folds are two peritoneal ligaments extending from the posterior aspect of the uterus to the sacrum.

The parametrium is a mass of fibrous and fatty tissue exceedingly rich in lymphatics, which is mainly found between the layers of the broad ligaments. It is especially thick around—(*a*) the uterine vessels and the ureter; (*b*) between the cervix and the bladder; and (*c*) in the utero-sacral folds. Septic inflammation of the uterus is frequently followed by parametritis.

The chief relations of the uterus are:—*anterior and inferior* — the utero-vesical pouch and the bladder; *superior*—the small intestine and the pelvic colon; *posterior*—the recto-uterine pouch, small intestine, and pelvic colon; *laterally*—the broad ligaments and ureters.

Blood-vessels of the Uterus.—The blood supply is derived from the uterine branches of the internal iliac, and from the uterine branches of the ovarian arteries. These vessels freely anastomose and give off numerous twigs to the uterus. During pregnancy the arteries greatly increase in size.

Each uterine artery after leaving the internal iliac, turns inwards along the upper surface of the levator ani to enter the base of the broad ligament. Here it crosses the ureter just above the lateral vaginal fornix, and divides into two, a large branch which ascends in a very tortuous manner along the side of the uterus, supplying the body and fundus, the ovary, the Fallopian tube, and the round ligament, and anastomosing with the ovarian artery, and also with the inferior epigastric along the round ligament; the smaller descending branch supplies the cervix and the upper part of the vagina, anastomosing with the vaginal artery. The uterine veins arise in the blood sinuses of the muscular coat, and communicate with the veins of the upper part of the vagina, thus forming the utero-vaginal plexus

around the ureter. The plexus opens into the internal iliac veins.

Lymphatic and Nerve Supply.—Lymphatic vessels are found in all the coats of the uterus; a few glands, the para-uterine glands, lie immediately external to the cervix. The main drainage is into the hypogastric nodes and the lumbar nodes. A few vessels accompany the round ligament and terminate in the inguinal group. The nerve supply is derived from the hypogastric, vesical, and utero-vaginal sympathetic plexuses, and from the second, third, and fourth sacral nerves. The uterus is connected with the last three dorsal, the first lumbar, and the second, third, and fourth sacral segments of the spinal cord.

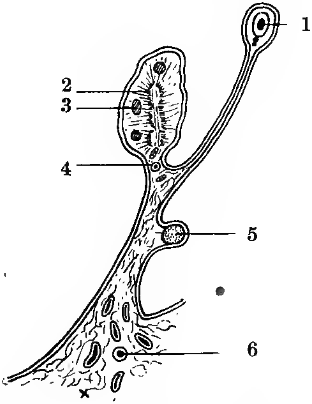
The Fallopian Tube.—The inner four-fifths of the upper border of the broad ligament surrounds the Fallopian tube, while from the remaining one-fifth arises a process of peritoneum, the infundibulo-pelvic ligament containing the ovarian vessels and nerves; it is ligatured in ovariotomy and in abdominal hysterectomy. Between the Fallopian tube and the ovary is an area of the broad ligament known as the meso-salpinx. Each Fallopian tube is four and a quarter inches long and about one quarter of an inch in diameter. It runs horizontally outwards from the uterus to the side wall of the pelvis: here it ascends over the superior pole of the ovary, then descends to abut against the inner surface of that organ. The tube opens into the uterus by the uterine ostium, and communicates with the peritoneal cavity by the abdominal ostium. From within outwards the parts of the tube are—(*a*) uterine; (*b*) isthmus; (*c*) ampulla, and (*d*) infundibulum with its fimbriated margins. The largest fimbria, the fimbria ovarica, passes to the upper pole of the ovary.

Both the uterine and the ovarian arteries send

branches to the Fallopian tube; the lymphatics open into the lumbar glands.

Septic inflammation of the uterus often extends into the Fallopian tube and causes salpingitis; from this the peritoneal cavity may become involved. Sometimes, however, the salpingitis leads to obliteration of the ostium abdominale, and pus collects in the tube,

Fig. 62.—Broad Ligament and its Contents (in Section). (After Testut.)



1. Fallopian tube, vessels, and mesentery (mesosalpinx).
2. Ovary.
3. Graafian follicle.
4. Anterior border of ovary (hilum), mesentery (mesovarium) containing ovarian artery and veins.
5. Round ligament of uterus.
6. Uterine artery in cellular tissue (parametrium) surrounded by uterine veins. The small cross indicates the position of the ureter.

pyosalpinx. Pregnancy may occur in the tube, causing rupture and internal hæmorrhage.

The Ovary.—The ovary is attached to the posterior surface of the broad ligament by a small peritoneal fold, the mesovarium. At the junction of the mesovarium with the germinal epithelium covering the ovary a faint white line will be noticed, In the nulliparous adult the

gland is 3 cms. long, 2 cms. from before backwards, and 1 cm. transversely; its long axis is almost vertical, and the gland occupies a peritoneal recess, the fossa ovarii, on the lateral wall of the pelvis. This fossa is bounded anteriorly by the obliterated hypogastric artery, posteriorly by the ureter, and superiorly by the external iliac vessels. In the floor of the fossa are the obturator vessels and nerve. When the tip of the appendix assumes a pelvic position, it forms an intimate relation of the right ovary.

The ovarian vessels and nerves descend in the infundibulo-pelvic ligament to the upper pole, then pass in the meso-ovarium to enter the hilum on the attached border of the organ. The lower pole is connected to the lateral margin of the uterus, just below and behind the entrance of the Fallopian tube, by a band of unstriped muscle called the ovarian ligament. Like the round ligament of the uterus, it is a remnant of the gubernaculum muscle which led to the descent of the ovary.

Blood-vessels and Nerve Supply.—The ovary is supplied by the ovarian and uterine arteries, the blood being returned by a plexus which terminates in a similar manner to the pampiniform plexus in the male. The lymphatics drain into the lumbar glands.

The nerves to the ovary accompany the ovarian vessels. They take origin from the aortic plexus, and communicate above with the renal plexus. The afferent fibres reach the spinal cord *via* the tenth thoracic nerve.

The Broad Ligament.—The broad ligament is a double fold of peritoneum stretching from the lateral margin of the uterus to the side wall of the pelvis. The portion between the Fallopian tube and the ovary is called the mesosalpinx.

Between the layers of each broad ligament are—(1) the Fallopian tube and tubal vessels; (2) the ep-öophoron (organ of Rosenmüller) and par-öophoron; (3) the ovary and its ligament; (4) the ovarian vessels; (5) the round ligament and its vessels; (6) the uterine vessels embedded in the parametrium. The ureter passes below the uterine vessels immediately beneath the base of the broad ligament.

The *ep-öophoron* is often called the parovarium. It consists of several blind tubules, the largest being the duct of Gärtner. Lying a little nearer to the uterus is another fœtal relic, the *par-öophoron*, also consisting of closed tubules. Both the ep-öophoron and the par-öophoron are vestiges of the Wolffian body (mesonephros), the duct of Gärtner representing the Wolffian duct. Remember that the ep-öophoron corresponds to the vasa efferentia and the epididymis, and the par-öophoron to the paradidymis. Cystic tumours, parovarian cysts, sometimes arise from the ep-öophoron.

The Female Ureter.—A knowledge of the exact course and relations of the pelvic portion of the ureter is of the greatest importance in gynecological surgery. After crossing in front of the internal iliac vessels and passing behind the ovary, the ureter runs beneath the base of the broad ligament embedded in the uterine venous plexus, but on a lower plane than the uterine artery. Here it lies three-quarters of an inch external to the supravaginal portion of the cervix, and about half an inch above the lateral vaginal fornix. It then converges towards its fellow of the opposite side, passing in front of the anterior wall of the vagina to enter the bladder one inch below the level of the external os.

The Round Ligament.—This is a fibro-muscular cord representing the lower portion of the gubernaculum. It is from five to six inches in length, and extends from

the lateral margin of the uterus, below and in front of the opening of the Fallopian tube, to the labium majus. In its course it crosses the obturator vessels and nerve, the obliterated hypogastric artery, the external iliac vessels, winds round the inferior epigastric artery and traverses the inguinal canal. It is frequently accompanied by a small process of peritoneum, the canal of Nuck, which may form the sac of a congenital hernia. Shortening of the round ligaments (the Alexander-Adams operation) is sometimes performed for backward displacement of the uterus.

The Vagina.—The long axis of the vagina is directed downwards and forwards with a slight convexity backwards. In adults the anterior wall is about three inches long, and the posterior wall three and a half inches. The recesses between the vaginal walls and the cervix uteri are termed the fornices. They are four in number—anterior, posterior, and two lateral; the posterior is the deepest. Carefully note the relations. The *anterior fornix* lies just behind the bladder, the remainder of the *anterior wall* being related to the bladder and the urethra. The posterior fornix is in contact with the utero-rectal pouch (pouch of Douglas), below this, the *posterior wall* is separated from the rectum by the pelvic fascia, and from the anal canal by the perineal body. Through the *lateral fornices* the terminal portion of the ureters can be reached, while in close relation with the *lateral walls* are the levatores ani muscles, which form a sphincter for the vaginal canal. The lower part of the vagina pierces the triangular ligament, while below this the vestibular bulbs, the vestibular glands (glands of Bartholin), and the sphincter vaginæ (bulbocavernosus) muscle form lateral relations. A spasmodic contraction of the sphincter vaginæ is called vaginismus. Laxity of

the vaginal walls may lead to the protrusion of a portion of the bladder (cystocele) or the rectum (rectocele) into the canal.

Blood-vessels and Nerves.—The upper part of the vagina is supplied by the cervical branch of the uterine artery, the middle part by the vaginal branch of the internal iliac, and the lower portion by the middle hæmorrhoidal and the internal pudic (pudendal). The lymphatic vessels pass to the hypogastric, iliac, and inguinal nodes. Both the utero-vaginal and the vesical plexuses contribute branches to the vagina, also the third and fourth sacral nerves.

The Urethra.—The female urethra is about one and a half inches long. It is directed downwards and forwards with a slight convexity backwards. As in the male the canal pierces the two layers of the triangular ligament. The external meatus will be found within the vestibule, one inch below the clitoris, and immediately in front of the vaginal orifice. The mucous membrane presents small lacunæ and near the external meatus is a group of glands, the para-urethral glands, which open into the vestibule by a common duct on each side. They are supposed to represent the prostate.

SECTION VI.

THE THORAX.

The Sternum and Ribs.—The anterior surface of the sternum is partly subcutaneous throughout. At the junction of the manubrium with the gladiolus or body is a well-marked transverse ridge, the sternal angle; as this lies opposite the second rib, it is an important landmark in the obese. At the end of expiration the sternum has the following relations to the spinal column—the upper border of the manubrium is opposite the second dorsal intervertebral disc; the lower border of the manubrium is opposite the body of the fifth dorsal; while the xiphoid process is opposite the body of the tenth dorsal vertebra.

Fractures of the sternum are rare, and when they occur are usually caused by severe direct violence; they are often accompanied by fracture-dislocation of the spine.

A congenital fissure or foramen is occasionally found in the sternum, owing to the imperfect ossification and failure of coalescence of its lateral halves.

The ribs may be broken by direct or indirect violence. When fractured by indirect violence, as by severe pressure on the front of the chest, the rib snaps at the point of its greatest convexity, and the fragments tend to be displaced outwards. Direct violence produces a fracture at the spot where the force is applied, there-

fore the fragments are forced inwards, and may penetrate any of the underlying structures, such as the lung and pleura, the heart and pericardium, the diaphragm, the liver, or the stomach. The fourth to the eighth ribs are those most commonly fractured; the first and second are very rarely injured, as they are protected by the clavicle and shoulder.

The Muscles of the Thoracic Wall.—The *external intercostals* extend as far forwards as the costo-chondral junctions. They are directed downwards and inwards from the lower margin of the upper rib bounding each space, to the upper border of the rib below. From the costo-chondral junctions to the edge of the sternum the muscular tissue is replaced by the anterior intercostal membrane. The *internal intercostals* connect the inner surfaces of the ribs, and run upwards and inwards. They stretch from the lateral sternal margin to the angles of the ribs, where they become continuous with the posterior intercostal membrane. Their deep surfaces are in contact anteriorly with the costal pleura and the triangularis sterni; posteriorly they are separated from the costal pleura by the subcostal muscles.

The Vessels of the Thoracic Wall. — The only vessels of importance in the thoracic wall are the internal mammary and the intercostals.

The internal mammary arises from the first part of the subclavian artery, below the origin of the thyreoid-axis (thyreo-cervical trunk); it passes behind the innominate vein and the sterno-clavicular articulation to descend in the thoracic wall as far as the sixth intercostal space, where it divides into two, the musculo-phrenic and the superior epigastric. In the superior mediastinum the artery is crossed superficially from without inwards by the phrenic nerve. The internal mammary is accompanied by two venæ comites and

a few lymphatic glands, the sternal glands. The artery is covered by the skin and fasciæ, pectoralis major, anterior intercostal membrane, internal intercostal muscles, and the costal cartilages; in the upper part of its course it rests upon the costal pleura, in the lower part upon the triangularis sterni. Above the level of the fourth rib the vessel is easily reached by an incision in an intercostal space, but below the fourth rib the intervals are so narrow that it is necessary to resect a cartilage in order to reach the bleeding artery.

The surface anatomy of the internal mammary is a line from the sterno-clavicular joint to the sixth intercostal space, lying half an inch external to the sternal margin.

Three intercostal arteries, two anterior and one posterior, are found in each of the first nine intercostal spaces; the tenth and eleventh spaces have no anterior arteries. The *anterior intercostals* of the upper six spaces arise from the internal mammary; those of the seventh, eighth, and ninth spaces from the musculo-phrenic. They pierce the internal intercostal muscles to anastomose with the posterior intercostal arteries. The first and second *posterior intercostals* spring from the superior intercostal, the remaining nine are branches of the descending aorta. Each posterior intercostal passes through the posterior intercostal membrane to gain the interval between the internal and external intercostal muscles. The posterior intercostals occupy the subcostal groove in the upper part of each space, and are accompanied by a vein and a nerve, the former running above, and the latter below the artery.

Paracentesis Thoracis—is usually carried out in the seventh or eighth interspace, a little external to the angle of the scapula. In performing this operation, care should be taken to introduce the trocar close to

the *upper* border of the lower rib of the space, so as to avoid injuring the intercostal vessels.

The Female Mamma.—The mammary gland extends vertically from the second rib to the sixth costal cartilage, and transversely from the lateral sternal margin to the anterior axillary line. A prolongation of the gland, the "axillary tail" of Spence passes into the axilla, and reaches as high as the third rib. The nipple usually lies opposite the fourth rib in the mid-clavicular line. It is surrounded by the *areola*, which varies in tint in different individuals, and in the same individual becomes darker during pregnancy. Small elevations (Montgomery's tubercles), are seen on the surface of the areola. They correspond to small glands which lie beneath the skin, and in which minute abscesses may form during lactation.

Occasionally supernumerary nipples (polythelia) are found, and the breast itself may exhibit curious anomalies; thus it may be absent (amazia), multiple (polymazia), or occur in some other situation as the groin or abdominal wall.

The breast has no definite capsule; it is placed in the superficial fascia, and rests upon the pectoralis major, and upon a small portion of the pectoralis minor, serratus anterior, and external oblique. "Fully one-third of the whole mamma lies inferior and external to the axillary border of the pectoralis major muscle" (Stiles).

Owing to the layer of connective tissue which lies beneath its base, the gland is freely movable on the surface of the pectoralis major, but in malignant disease of the breast, this connective tissue becomes involved, and the breast is rendered more adherent to the underlying muscles.

The breast consists of a compact mass of secreting

tissue and stroma, the corpus mammæ, surrounded by a variable amount of adipose tissue, the paramammary fat. From the corpus mammæ connective-tissue processes radiate in all directions. The deep processes extend into the pectoral fascia; the lateral ones penetrate the paramammary fat; and the superior group are mainly adherent to the skin in the vicinity of the areola. The latter bands are termed the suspensory ligaments of Cooper. Traction upon these ligaments leads to tacking down of the skin.

The secreting tissue is made up of racemose tubules arranged in lobes and terminating in ducts. These milk-ducts are from fifteen to twenty in number, and converge towards the nipple. In the region of the areola they dilate, forming ampullæ, then narrow again to traverse the nipple and open upon its summit. When by the contraction of newly-formed fibrous tissue the milk-ducts are dragged upon, the nipple is retracted. The lobes are separated by fibrous septa of connective tissue, continuous with that which covers the superficial and deep surfaces of the gland. For this reason an abscess in the breast is usually multilocular, and when opened, the septa should be broken down with the finger so as to ensure drainage of the whole cavity. In opening a mammary abscess the incision should radiate from the nipple, so that, if possible, the ducts may not be injured.

Vascular and Nerve Supply.—The arteries supplying the mammary gland are the third and fourth perforating branches of the internal mammary, the first three aortic intercostals, and the lateral thoracic branch of the axillary. The veins form a circular plexus around the periphery of the gland, from which trunks arise to terminate in the internal mammary venæ comites, the axillary vein, and the venæ azygos major and minor

superior. The nerves are derived from the intercostal nerves of the spaces upon which the breast lies.

Lymphatics.—The lymphatic vessels of the breast are arranged in the following groups which freely communicate with each other:—

(*a*) Cutaneous.
(*b*) Sub-areolar plexus.
(*c*) Circummammary.
(*d*) Retromammary.
(*e*) Intramammary $\left\{\begin{array}{l}\text{Periacinar.}\\\text{Periductal.}\end{array}\right.$

The vessels issuing from the outer border of the mamma pass to the pectoral group of glands, the central glands of Leaf, the subscapular nodes, the glands accompanying the axillary vein, and the subclavicular glands in the apex of the axilla (*see* Axilla). When the glands around the axillary vein become involved in malignant disease of the breast, elephantiasis of the arm may result. From the inner border of the mamma the vessels follow the perforating arteries to the sternal glands. Other vessels emerge from the lower and inner borders, and pass to a lymphatic plexus situated in the fascia over the epigastrium, from which they are connected along the ligamentum teres of the liver to the lymphatics of the liver and peritoneum. The vessels issuing from the deep surface go to some small glands lying between the pectoral muscles and on the superior thoracic artery, others pass to the infraclavicular nodes.

THE PLEURÆ AND LUNGS.

The Pleuræ.—For descriptive purposes the parietal pleura is divided into the costal, diaphragmatic, mediastinal, and cervical portions. The cervical part is strengthened by Sibson's fascia, which extends from the

transverse processes of the lower cervical vertebræ to the apex of the pleural sac. Remember that the costal pleura is very tough and is separated from the parietes by the endo-thoracic fascia, while on the other hand the diaphragmatic pleura is thin and is firmly connected to the underlying muscle. With the exception of the root, the visceral pleura surrounds every part of the lung, and in addition lines its various fissures. More delicate in texture than the parietal pleura, it is adherent to the pulmonary substance. In some cases of chronic empyema where the lung has been bound down by adhesions, it is necessary to strip off a part of the visceral pleura, an operation known as "decortication of the lung." As might be expected, such a procedure is accompanied by considerable hæmorrhage and shock. Passing from the inner surface of the lung to the pericardium is a triangular fold of pleura, the *ligamentum latum pulmonis*.

The Lungs.—Each lung possesses an apex, a base, two borders, and two surfaces. The *apex* extends upwards for about one inch above the anterior part of the first rib. It is closely related to the subclavian, internal mammary, and superior intercostal arteries. The *base* of the right lung is more concave than that of the left; it rests upon the diaphragm beneath which is the right lobe of the liver, while the base of the left lung is separated from the left lobe of the liver, the stomach, and the spleen, by the left cupola of the diaphragm. The *anterior border* descends in front of the pericardium, and on the left side presents the incisura cardiaca. The *posterior border* is lodged within the costo-vertebral recess. The *external surface* fits against the parietes, being moulded by the ribs. The *internal or mediastinal surface* has somewhat different relations in each lung. This surface of the right lung is impressed by the heart,

the superior vena cava, the innominate artery, the vena azygos major, and the œsophagus. Related to the left lung are the heart, the aortic arch, and descending aorta, the left innominate vein, the left subclavian artery, and the œsophagus.

The *root* of the lung is made up of (1) a pulmonary artery; (2) two pulmonary veins; (3) a bronchus; (4) twigs from the pulmonary nerve plexuses; (5) bronchial vessels; and (6) some lymphatic glands. From before backwards the arrangement of the chief structures is—veins, artery, and bronchus. From above downwards in the root of the right lung the order is—eparterial bronchus, artery, hyparterial bronchus, and veins; in the left root the eparterial bronchus is absent. The chief relations of the roots of the lungs are:—

Root of right lung—

Above.

Vena azygos major.

Anterior. $\boxed{\text{R}}$ *Posterior.*

Anterior.	Posterior.
Anterior pulmonary plexus.	Posterior pulmonary plexus.
Phrenic nerve.	
Comes nervi phrenici artery.	
Superior vena cava.	

Below.

Ligamentum latum pulmonis.

Root of left Lung—

Above.

Aortic arch.

Anterior. $\boxed{\text{R}}$ *Posterior.*

Anterior pulmonary plexus.	Posterior pulmonary plexus.
Phrenic nerve.	Descending aorta.
Comes nervi phrenici artery.	

Below.

Ligamentum latum pulmonis.

Surface Anatomy of Pleuræ and Lungs.—The line of the *pleural sacs* commences behind opposite the seventh cervical spine, and descends vertically, lying just external to the vertebral spines as far as a point half an inch below the twelfth rib. Here it turns horizontally outwards, cutting the scapular line in the eleventh interspace, the mid-axillary line in the tenth interspace, and the mammary line opposite the eighth rib. From this level the line ascends obliquely to the seventh chondro-sternal junction, where the pleura passes upwards behind the middle of the sternum to the sternal angle; the left pleura, however, coincides with the lateral sternal margin until the fourth costal cartilage is reached, where it turns inwards and then ascends behind the sternum to the sternal angle. Above this angle the two sacs diverge, passing behind the sterno-clavicular joint to reach a point one inch above the clavicle.

The *lungs* only descend to the tenth interspace at the vertebral column, the tenth rib in the scapular line, the eighth rib in the mid-axillary line, the sixth rib in the mammary line, and reach the sternum at the sixth chondro-sternal junction. The incisura cardiaca commences behind the sternum opposite the fourth costal cartilage, and extends outwards along the inner half of this cartilage on the left side; it then turns downwards and inwards to the sixth chondro-sternal junction.

THE MEDIASTINA.

The interval between the two pleural sacs is divided into the superior, anterior, middle, and posterior mediastina.

The Superior Mediastinum.—Boundaries: *Superior*, the inlet of the thorax; *inferior*, an imaginary plane passing through the sternal angle in front and the body of the fourth dorsal vertebra behind; *anterior*, the manubrium sterni; *posterior*, the bodies of the upper four dorsal vertebræ. Within this space the main structures are (*a*) the aortic arch with the innominate, left common carotid, and left subclavian branches; (*b*) the two innominate veins uniting to form the superior vena cava; (*c*) the œsophagus, trachea, and thoracic duct; (*d*) the thymus gland, or its remains in the adult; and (*e*) the phrenic, pneumogastric, and the left recurrent laryngeal nerves. The left phrenic and left pneumogastric nerves cross the aortic arch superficially, while the left recurrent laryngeal nerve hooks round the ligamentum arteriosum, which lies beneath the aortic arch, and then ascends on the deep aspect of the arch.

The Innominate Artery.—To mark out this vessel take a line from a point a little to the right of the middle of the sternum, to the sterno-clavicular joint. Aneurysm of the artery is not uncommon. The innominate has on several occasions been ligatured successfully; the operation, however, is of the most formidable nature. The chief relations are:

Anterior.

Manubrium sterni.
Sterno-hyoid and sterno-thyreoid.
Left innominate vein.
Remains of thymus.

Right.		*Left*
Right innominate vein.		Trachea.
Superior vena cava.	(A)	Inferior thyreoid veins.
Right pneumogastric.		Origin of left common carotid.

Posterior.

Trachea.
Right pleural sac.

The Superior Vena Cava.—The two innominate veins unite behind the first right chondro-sternal junction to form the superior vena cava. About three inches long, it terminates in the upper and back part of the right auricle. The lower half of the vein lies within the fibrous pericardium. Just before entering the pericardium it receives the vena azygos major.

The Thymus Gland.—The thymus gland is formed by the coalescence of two entodermal outgrowths from the third inner branchial cleft depression. Well-formed at birth, it gradually increases in size until puberty, after which it slowly decreases. It is commonly slightly larger in females than in males. In young children it may be so large as to seriously embarrass respiration, and to lead to thymic asthma. The condition known as status lymphaticus is always associated with an enlarged or persistent thymus.

The thymus mainly occupies the superior mediastinum, and rests upon the pericardium and the great vessels. The blood supply is derived from the inferior thyreoid and internal mammary arteries.

The Anterior Mediastinum. — This space is bounded *above* by the imaginary plane separating it from the superior mediastinum; *below* by the diaphragm; in *front* by the gladiolus of the sternum, and

behind by the anterior layer of the pericardium. It contains a little areolar tissue, a few lymphatics, and some twigs from the internal mammary artery.

The Middle Mediastinum.—The middle mediastinum is limited in front and behind by the pericardium; its superior and inferior boundaries are similar to those of the anterior mediastinum.

Within this area are found the heart and the big vessels, the phrenic nerves, the comes nervi phrenici arteries, and the roots of the lungs.

The Posterior Mediastinum.—From a surgical standpoint, the posterior is the most important mediastinum. It lies between the posterior layer of the pericardium and the bodies of the lower eight dorsal vertebræ, the superior and inferior limits corresponding with those of the anterior and middle mediastina. The chief contents are—(*a*) the œsophagus; (*b*) the pneumogastric and the splanchnic nerves; (*c*) the thoracic duct; (*d*) the descending aorta; (*e*) the venæ azygos; and (*f*) lymphatic glands.

PERICARDIUM AND HEART.

The pericardial sac occupies the middle mediastinum. Its chief relations are—*anterior*, it is overlapped by the pleural sacs and the anterior margins of the lungs; *posterior*, the contents of the posterior mediastinum, especially the œsophagus; *laterally*, the mediastinal pleuræ, and the phrenic nerves with their accompanying arteries; *inferior*, the central tendon and a small portion of the left cupola of the diaphragm. Within the fibrous pericardium will be found the serous layer. This lines the fibrous pericardium, the parietal layer, and also covers the heart and certain portions of the big vessels, the visceral layer, or the epicardium. The

serous pericardium has two easily-defined recesses—(*a*) between the auricles behind, and the common sheath for the aorta and pulmonary artery in front, the *transverse sinus;* and (*b*) between the auricles and the posterior layer of the pericardium, the *oblique sinus*. The apex of the fibrous pericardium corresponds to the second right chondro-sternal articulation. At this point the pericardium blends with the wall of the aorta.

Paracentesis of the pericardium is performed in the fifth or sixth intercostal spaces, in the mammary line. When drainage is required a small portion of the fifth rib may be removed.

The outline of the heart can be traced as follows—a line slightly convex outwards from the third to the sixth right chondro-sternal junctions will represent the right border; a line from the sixth right chondro-sternal junction to a point in the fifth left interspace, three and a half inches from the mesial plane, corresponds to the lower border; while a line from the last point to the second left interspace, half an inch from the sternal margin, marks out the left border. The anterior surface of the heart mainly consists of the right ventricle, a portion of the right auricle, and about half an inch of the left ventricle. Of these, the right ventricle is the part most liable to injury from punctured wounds. Owing to the thinness of its wall, wounds of the right auricle are almost invariably fatal. The right auricle receives the superior vena cava, the inferior vena cava, and the cardiac veins. It opens into the right ventricle by the tricuspid orifice which is guarded by the valve of the same name. Springing from the conus arteriosus of the right ventricle is the pulmonary artery. The semilunar valves prevent the regurgitation of blood from the artery into the ventricle. The four pulmonary veins terminate in the left auricle, and from this chamber the

blood-stream enters the left ventricle through the mitral orifice which is guarded by the mitral or bicuspid valve. The aorta arises from the vestibule of the left ventricle. Its valve, like that of the pulmonary artery, consists of three semilunar cusps.

The heart is supplied by the coronary branches of the ascending aorta. The right coronary occupies the right auriclo-ventricular groove, and sends a descending branch along the posterior inter-ventricular sulcus. The left coronary runs in the left auriculo-ventricular furrow, and gives off a descending branch which lies in the anterior inter-ventricular groove, and is accompanied by the great cardiac vein. There is no direct anastomosis between the two coronary arteries.

THE AORTA.

Aneurysm of the thoracic aorta is of common occurrence. The ascending and the transverse parts are more frequently affected than the descending portion. The branches of the aorta are—*from the ascending part*, the right and left coronary; *from the transverse part*, the innominate, the left common carotid, and the left subclavian; *from the descending portion*, the posterior intercostal, the bronchial, the subcostal, and the branches to the œsophagus, posterior mediastinum, and pericardium. The extent and chief relations of the aorta are—

Ascending Part.—From the third chondro-sternal junction on the left, to the second chondro-sternal junction on the right.

Anterior.

Pulmonary artery.
Right auricular appendix.
Pericardium.
Right lung and pleura.

Right.		*Left.*
Right auricle. Superior vena cava.	**A**	Pulmonary artery.

Posterior.

Right pulmonary artery.
Left auricle.

Transverse Part.—From the termination of the ascending aorta to the body of the fourth dorsal vertebra.

Superior.

Left innominate vein.
Innominate, left common carotid, and subclavian arteries.

Right.		*Left.*
Trachea. Œsophagus. Thoracic duct. Left recurrent laryngeal nerve.	**A**	Cardiac nerves. Left vagus. Left phrenic. Remains of thymus gland.

Inferior.

Bifurcation of pulmonary artery.
Ligamentum arteriosum.
Left bronchus.
Left recurrent laryngeal nerve.

Descending Part.—From the body of the fourth dorsal vertebra to the body of the twelfth dorsal.

Anterior.

Root of left lung.
Pericardium.
Œsophagus.
Diaphragm.

Right.		*Left.*
Œsophagus (*above*).	**A**	Left lung and pleura.
Vena azygos major.		Œsophagus (*below*).
Thoracic duct.		

Posterior.
Vertebral column.
Venæ azygos minor.

The Azygos Veins.—The azygos veins by linking together the superior and inferior venæ cavæ, form important anastomosing channels when the inferior vena cava is obstructed from any cause.

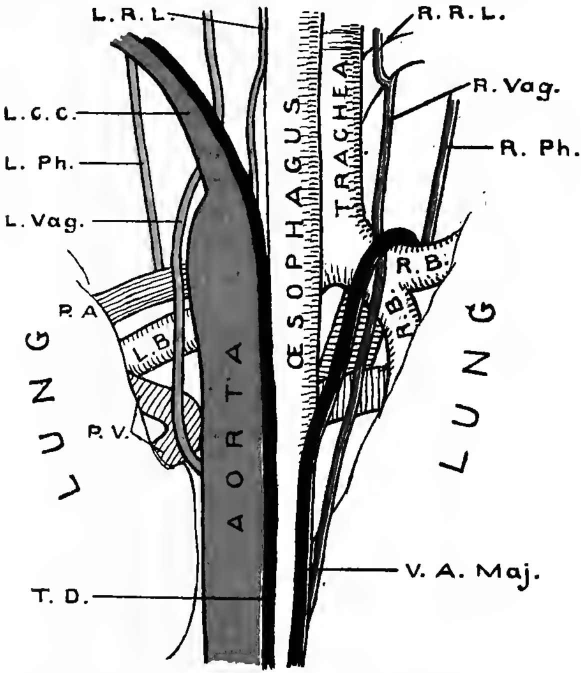
The vena azygos major arises from the right ascending lumbar vein, and passes through the aortic orifice of the diaphragm, on the right side of the thoracic duct and the aorta. In its thoracic course it rests upon the bodies of the dorsal vertebræ and has the thoracic duct and aorta upon its left side; lastly, it hooks around the right bronchus, to enter the superior vena cava. With the exception of the first intercostal, the vena azygos major receives all the right intercostal veins, the right bronchial veins, and the œsophageal veins. On the left side of the thorax two venæ azygos are found; the superior of which connects the left innominate to the vena azygos major, while the inferior takes origin from the left ascending lumbar vein, and also terminates in the vena azygos major.

The Œsophagus.—It is convenient to study the œsophagus throughout its whole course.

The œsophagus commences at the level of the cricoid cartilage, which is opposite the sixth cervical intervertebral disc, and terminates in the cardia of the stomach opposite the eleventh thoracic vertebra. The total length in adults is 10 inches (25 cms.). In the

neck the œsophagus lies behind the trachea, and in front of the prevertebral fascia and longus colli muscles. It deviates slightly towards the left side, and comes into

Fig. 63.—Dissection of the Posterior Mediastinum.



L.B.	Left Bronchus.	R.B.	Right Bronchus.
L.C.C.	Left Common Carotid.	R.Ph.	Right Phrenic.
L.Ph.	Left Phrenic.	R.R L.	Right Recurrent Laryngeal.
L.R.L.	Left Recurrent Laryngeal.	R.Vag.	Right Vagus.
L.Vag.	Left Vagus.	T.D.	Thoracic Duct.
P.A.	Pulmonary Artery.	V.A. Maj.	Vena Azygos Major.
P.V.	Pulmonary Vein.		

relation laterally with the thyreoid body, carotid sheaths, inferior thyreoid arteries, and the recurrent laryngeal nerves.

In the thorax the œsophagus passes down behind the trachea and the arch of the aorta, and traverses the posterior mediastinum along with the descending aorta, crossing this vessel superficially from right to left at the level of the eighth thoracic vertebra. It is in contact with both pleural sacs; the left bronchus lies in front; the thoracic duct and a variable portion of the vena azygos major are behind. The thoracic duct crosses behind the œsophagus opposite the aortic arch, and then ascends along its left margin. The two vagi nerves form a plexus, the plexus gullæ, around the œsophagus, but as the œsophagus passes through the diaphragm, the left vagus lies in front and the right vagus behind. Notice that the abdominal portion of the œsophagus is about half an inch long, and is non-peritoneal on its posterior and right aspect.

Aneurysm of the aorta, or of one of its large branches may, by pressure on the gullet, give rise to difficulty of deglutition. Hence the surgeon should exclude the possibility of aneurysm being present before introducing an œsophageal bougie.

Foreign bodies are apt to be arrested at one of the three constricted portions—

(i) At the cricord . .	6 inches (15 cms.) from the incisor teeth.
(ii) Opposite the left bronchus . .	10 inches (25 cms.) from the incisor teeth.
(iii.) At the diaphragm .	15-16 inches (40 cms.) from the incisor teeth.

The congenital anomalies of the œsophagus which may occur are: (*a*) absence of the lower part; (*b*) a communication with the trachea; (*c*) double œsophagus; and (*d*) congenital annular strictures. True diverticula are acquired. They are usually found in the upper part of the œsophagus, and are due to a hernia of the œso-

phagus through the inferior constrictor muscle (Mosher). Strictures of the œsophagus may be of a benign or of a malignant nature. The benign variety most frequently follows the swallowing of corrosive fluids; the malignant form is an epithelioma. The constricted parts of the tube are the common sites of stricture.

Blood-vessels and Lymphatics. — The arterial supply is derived from five sources, namely—the inferior thyreoid, bronchial arteries, descending thoracic aorta, left gastric, and left inferior phrenic. The veins terminate in the inferior thyreoid, venæ azygos, and left gastric vein, and thus into both the systemic and the portal systems. The lymphatic vessels drain into the lower group of the deep cervical chain, and the posterior mediastinal glands.

JOINTS OF THE THORAX.

Costo-vertebral Joints.—The joints between the heads of the ribs and the bodies and discs of the vertebræ are termed *capitular*. Two ligaments are found:—(*a*) the stellate, and (*b*) an interarticular, the latter being absent in the case of the first and the last three ribs. The stellate ligament usually consists of three bands, which arise from the anterior part of the head of the rib, and pass to the bodies of the two adjacent vertebræ and the intervening intervertebral disc. Only two bands are present in the first, tenth, eleventh, and twelfth joints. Each interarticular ligament extends from the ridge on the head of the rib to the intervertebral disc; it separates the joint into two synovial cavities. The *costo-transverse* articulations have capsular, superior, middle, and posterior ligaments. A single synovial membrane lines each joint. The posterior ligament passes from the tip of the transverse

process to the non-articular part of the tubercle of the rib. The middle ligament connects the neck of the rib to the anterior part of the transverse process. The superior costo-transverse ligament goes from the upper margin of the neck to the lower part of the transverse process immediately above it.

Manubrio-gladiolar Joint.—Three ligaments connect these segments of the sternum, namely, an anterior, a posterior, and an intermediate fibro-cartilage. The posterior ligament is much stronger than the anterior one.

Sterno-chondral Joints.—The first seven costal cartilages articulate with the sternum. Anterior and posterior ligaments are found in each joint, and, in addition, an interarticular ligament is present in the second joint. The first joint has no synovial cavity the second joint possesses two, and the remaining joints have one.

APPENDIX

THE EPIPHYSES AND THEIR OSSIFICATION.

In the long bones, the medullary arteries are directed towards the elbow in the upper extremity, and away from the knee in the lower extremity. Bones which possess only one epiphysis—*i.e.*, clavicles, metacarpals, and phalanges—have their nutrient arteries directed away from the epiphyses. The long bones have epiphyses at both extremities, and that epiphysis towards which the nutrient artery is directed is the first to join the shaft, but is the last in which ossification commences. The only exception to this rule is the lower end of the fibula, which joins first and ossifies first.

Accordingly, growth in length chiefly occurs at the knee, the shoulder, and the wrist.

It is generally taught that bone increases in girth because of the activity of the osteoblasts in the deep layer of the periosteum. Macewan, however, has re-investigated this point, and has come to the conclusion that periosteum does not produce bone, but actually limits its production, and all increase in thickness is due to the osteoblasts of the bone itself. The following is a resumé of some of his chief experiments.

(*a*) A strip of periosteum was dissected up from the radius of a dog, leaving the epiphyseal attachment intact; the free end was buried between the adjacent muscles. Eight weeks later the buried periosteum had degenerated into a fibrous band, and a long outgrowth had occurred from the denuded area of the radius.

(*b*) A strip of periosteum was removed and implanted into the neck muscles of the animal; the periosteal strip did not form any new bone, but was completely absorbed.

(*c*) Portions of the whole length of a bone were removed subperiosteally; no new periosteal bone was formed.

(*d*) The periosteum was dissected off an area of bone, and a silver ring fitted over the bare area; new bone could be observed growing over the edges of the ring.

(*e*) If thin shavings of bone are transplanted they increase in size, often doubling in length and thickness.

Table of the Main Epiphyses.

Bone.	Part.	Year when joins Shaft.
Clavicle	Sternal end	25th.
Scapula	Coracoid process	15th.
	Acromion process	22nd-25th.
Humerus	Upper extremity	20th.
	Lower extremity	17th.
	Internal epicondyle	18th.
Radius	Upper extremity	17th.
	Lower extremity	20th.
Ulna	Olecranon process	17th.
	Lower extremity	18th-20th.
Metacarpals and phalanges	In the metacarpals the epiphysis is distal, except in the thumb, where it is proximal. The epiphyses of the phalanges are proximal	20th.
Os innominatum	Rami of ischium and pubes	8th.
	Elements of acetabulum	18th-20th.
	Epiphyses for anterior inferior spine, iliac crest, tuber ischii, and pubic spine	20th.

Bone.	Part.	Year when joins Shaft.
Femur	Head	19th.
	Lower extremity	20th.
	Great trochanter	18th.
	Lesser trochanter	17th.
Tibia	Upper extremity	21st-22nd.
	Lower extremity	18th.
Fibula	Upper extremity	22nd-23rd.
	Lower extremity	20th.
Metatarsals and phalanges	Correspond with metacarpals and phalanges of hand	20th.

Dimensions of the Female Pelvis.

A.—*Internal measurement in inches.*

	Inlet.	Cavity.	Outlet.
Antero-posterior	$4\frac{1}{4}$	$4\frac{1}{2}$	5
Oblique	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$
Transverse	5	$4\frac{1}{2}$	5

B.—*External measurements in inches.*

External conjugate, *i.e.*, from last lumbar spine to upper border of symphysis pubis $7\frac{1}{2}$

Interspinous, *i.e.*, connecting the anterior superior iliac spines 10

Bi-iliac, *i.e.*, between the widest parts of the iliac crests - 11

Inter-trochanteric, *i.e.*, between the great trochanters of the femur - 12

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PRINTED BY J. & J. GRAY & CO., ST JAMES PLACE, EDINBURGH.